COLD STORAGE PRACTICE

BY

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PREFACE

This book is not intended as a treatise on refrigeration. It is a guide to Cold Store Operation—the work entailed in receiving, storing, and delivering refrigerated goods ; in other words, refrigerated warehousing.

Care has been taken to avoid technicalities. Refrigerating engineering and cold store construction are, of course, closely allied with cold storage operation, but to deal fully with all three subjects in one small book would be impossible. Not many of those engaged in actual refrigerated warehousing have the time or the opportunity to extend their knowledge into the scientific aspects of cold storage work. These notes endeavour to cover and explain the practical side of operating cold stores and, at the same time, to describe some of the main features of the commodities handled.

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December, 1947.

FOREWORD

To maintain perishable foodstuffs in perfect condition and to eliminate all avoidable waste, it is essential that those concerned with the handling of these commodities at every stage, from the producer to the consumer, should know exactly how each should be handled, the correct method of stowing, and the most suitable storage conditions. The maintenance of proper records of all matters pertaining to the running of the store and of the goods passing through it is another important part of a cold store manager's duties.

In the past, cold store management has been based entirely on experience handed down from one generation of managers to the next. There has been no other training which a prospective manager could undergo, and no single textbook to which he could refer for information on all essential cold-storage matters.

In writing this comprehensive book, giving authentic information on the many problems associated with cold store management, Mr. Miller has rendered an outstanding service to the cold storage industry, and the book should prove of great value and assistance to all those who are in any way concerned with the operation of cold stores.

KENNETH LIGHTFOOT,

President, National Federation of Cold Stores and Ice Trades.

CONTENTS

CHAPTER 1

WHAT ARE COLD STORES?

COLD Stores are warehouses built specially for the storage of refrigerated foods. Refrigerated foods are foodstuffs that have been frozen or chilled by mechanical means in order to prolong their preservation. Foodstuffs are preserved in several ways; by salting, curing, canning, dehydration, and so on. Preserving by refrigeration is not a new science. It is, however, only during the last fifty years or so that it has been extensively practised in a commercial way.

The importation of frozen and chilled foods into Great Britain has increased tremendously during the last twenty years. The present value of refrigerated imports exceeds the vast sum of £90,000,000 per annum.

Such a huge value represents in quantity a great many tons. Refrigerated ships, vessels with insulated holds and refrigerating machinery for maintaining low temperatures, bring their cargoes of meats, dairy produce, and fruits into British ports. When these cargoes are unloaded they cannot be put into an ordinary dock warehouse, but must be stored in specially built warehouses, where the same temperature as that of the refrigerated holds can be maintained. This temperature, for frozen goods, is normally as low as 14° Fahr.

These specially built warehouses are of concrete, stone, or brick, but the walls, ceilings, and floors are insulated with a special thermal insulating material, usually slab cork. The doors are specially constructed, and are also insulated. The warehouse is divided into a number of rooms of convenient capacity, cooled either by circulating cold air through air ducts, or circulating cold brine or ammonia or other refrigerating medium through pipe coils suspended from ceilings and walls.

It has been long agreed among cold storage operators that cold storage work should be made as interesting, easy, and attractive as possible. In the majority of cold stores the work is extremely hard, and is not made attractive by the conditions under which it must be carried out.

Cold store evils can generally be traced to the design and construction of the stores themselves, to the equipment, and to the maintenance of buildings and machinery. With the older stores little can be done about design and construction. The more modern stores are designed to eliminate these evils.

The management and operation of a cold store can tend either to eliminate or to create evils. This manual is written as a guide towards better management and operation, and to help in establishing a code of good cold store practice.

There are a number of stores in this country classified by Lloyds. Bu Lloyds classify a store entirely on its ability to maintain certain temperature Structurally, the building may be sound, the insulation good, and th refrigerating plant mechanically efficient. But this is no authority for sayin that because it is a reasonably good cold store it will demonstrate good col storage.

Few cold store operators understand the elements of refrigeration, but a are concerned with it. The ordinary cold storage warehouseman should under stand and appreciate what is going on in the engine room, and how the col in the chambers is produced and maintained.

Without, at least, an elementary knowledge of cold storage principles, th man handling meats and fruits and dairy produce cannot appreciate how moul —that great enemy of the cold storage industry—is germinated, nor how i can be defeated and prevented.

The average cold store operator should be equally as interested in goo cold store practice as is the management. Managements should be far mor interested than they have been. The correct definition of good cold stor practice is *to handle the greatest quantity of goods in the shortest possible time in the easiest cleanest way, at the lowest minimum cost, and to keep those goods i cold storage without loss of weight, freshness, or quality, for as long as is necessary*

The main reason for writing this book is to impress the above guidin principles on all who are connected in any way with cold stores. The boo is written in language that can be understood by all grades of cold storag operators, from the manager down to the lift boy. Technicalities, so far as i possible, have been avoided. Simplicity and conciseness have been aimed at A clear picture of the work and problems to be met with in all cold store has been presented.

Good cold store practice is possible in all cold stores—new and old. Nev stores will find it easier, of course. But old stores can have new equipment There is a big field for invention in new equipment. There is vast room fo improvement in cold store design from the operating point of view. A lc of attention and research work has been given to the design of refrigeratin plant. It is time something was done to facilitate the actual work of handlin cold storage goods.

CONSTRUCTION OF COLD STORES

Main Features

The lay-out of the main structure of any cold store, and the design of tl plant depends upon the class of business to be done. Locality and choice site are determined by the business, or, as is often the case, *vice versa*.

In describing the main features of cold store construction it will be necessa to speak of a general cold store or of a building suitable only for general co storage warehousing of meats, fish, fruits, and dairy produce.

An estimate is necessary, at the beginning, of the total approximate tonnage to be stored, and the approximate amount of tonnage movement daily.

. If the storage tonnage is known an estimate can be made of the cubic capacity.

Cold stores are always described as being of so many thousand cubic feet capacity. This capacity is internal volume of the net storage capacity space only, and does not include loading banks, staircases, or any space outside the rooms where walls, ceilings, and floors are not insulated.

A small cold store is not profitable. Revenue depends entirely on net storage space. Costs of construction vary inversely with capacity. For example, a million cubic feet capacity store may cost 5s. per cubic foot to build and equip. A store of the same design and with the same equipment, but only half the capacity, may cost, probably, 7s. 6d. per cubic foot.

On the other hand a large cold store, too large for the business, entails capital represented by expenditure on over-capacity, capacity which, due to lack of business, is non-revenue earning. Tied up capital is lost money. In fact, it is a liability because it appears in the form of depreciation, etc., as a charge—and therefore an operational cost—on the cold store balance sheet.

In practice, also, it is learned that the gross income of the average cold store works out at approximately sixpence to eightpence per cubic foot of net storage space per week, which is not a very big return. The greater the number of cubic feet of unoccupied storage space the smaller the amount of income per cubic foot per week.

It follows, therefore, that the capacity of a cold store is of first importance, and local needs, competitive capacity, and area to be served, must be very closely studied.

All factors relative to location must be fully considered. Railway facilities and, if near a port, quayside proximity and local docking regulations and conditions, must be weighed against cartage charges.

Design of Building

There are three important considerations in design. First, the number of storage rooms and the number of chilling rooms. Second, the number of floors. Third, the position of the loading bank and the number of lifts.

Experience has shown that in general warehousing a quarter of the total space only is necessary for chilling. It is, however, common practice in many areas to have storage rooms so arranged that they can be utilised as chillers whenever trade necessitates it. The size of chambers affects the number. There are disadvantages with rooms having a capacity for more than 150 tons. Smaller rooms also have their disadvantages. On the other hand, where trade is such that storage of numerous small consignments is required, smaller chambers are obviously more suitable.

The number of floors is governed principally by location. If the store is in a closely built-up area, space can be obtained only by height. Height means

lifts. Lifts slow up handling of goods and cause increased costs of receivin and delivery.

There are cold stores of seven floors and a basement. There are other which are constructed entirely on the one floor principle. Others—mostl city stores—are basement chambers. These are usually built under the market Their distinct advantage is that because of their basement position the co of insulation is reduced to a minimum.

Insulation of a cold store is a costly item, and outside wall insulation mus necessarily be thicker than that of dividing walls.

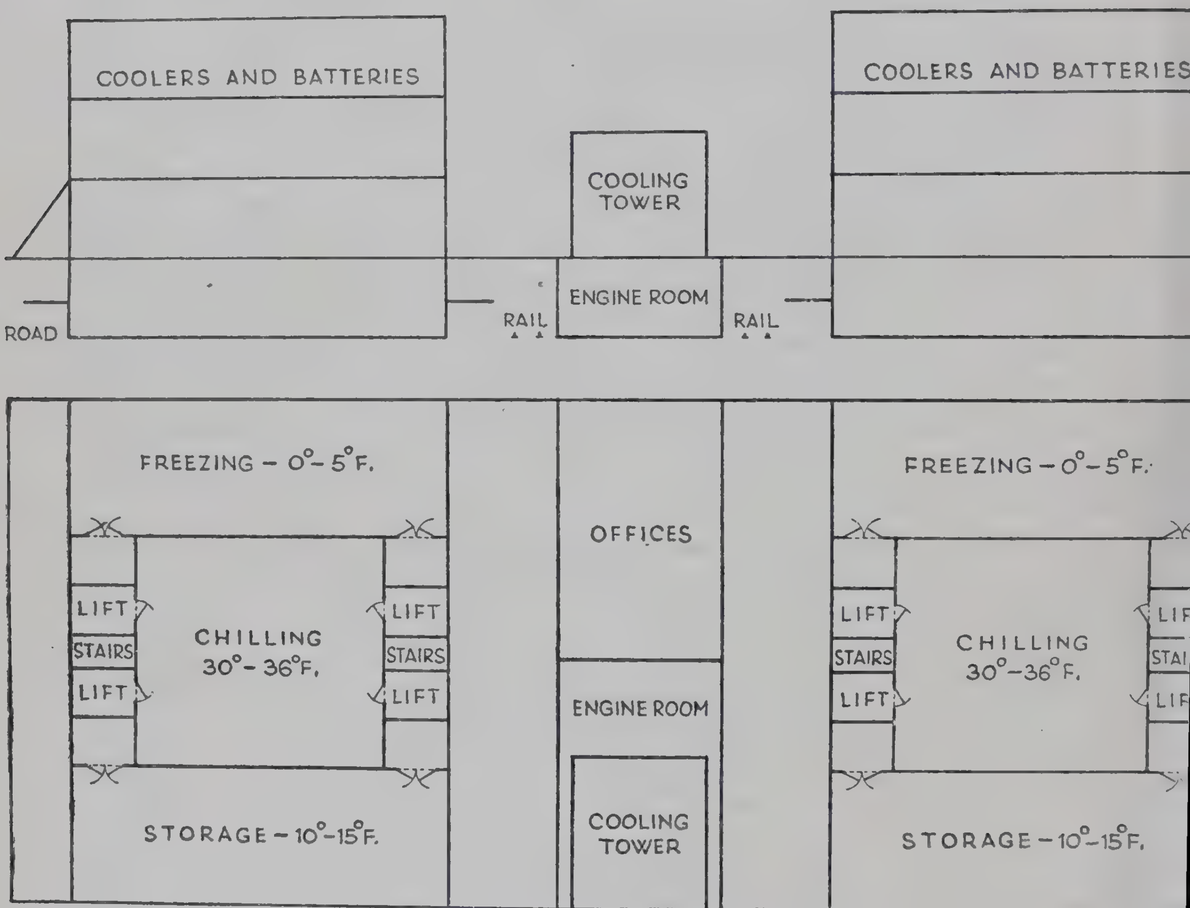


Fig. 1.—Design for 1,500 Tons Store.

It follows, therefore, that the floor, roof, and the four outside walls w be of considerable square foot area. It is necessary to calculate, where spa and location permit of a choice of either height or floor area, whether the to square foot area of outside insulation necessary will be greater for a long sin store building or a short high building.

It will be seen that there is more than one determining factor governi design and that the most important one is cost.

Experience has shown that chambers 50 ft. long by 30 ft. wide, construct to a three-storey design accommodating an equal number of chambers

each floor, is the most practical plan. Close study of such an arrangement of chambers reveals that the advantages far outweigh the disadvantages.

Thus, it would appear that the ideal cold store assumes the shape of a cube —a square building, as high as it is long and broad.

As stated above, and to summarize, the outside surface area of any cold store is of supreme importance. The greater the area, the greater the load on the refrigerating plant, and the greater the effect on plant running hours and plant costs.

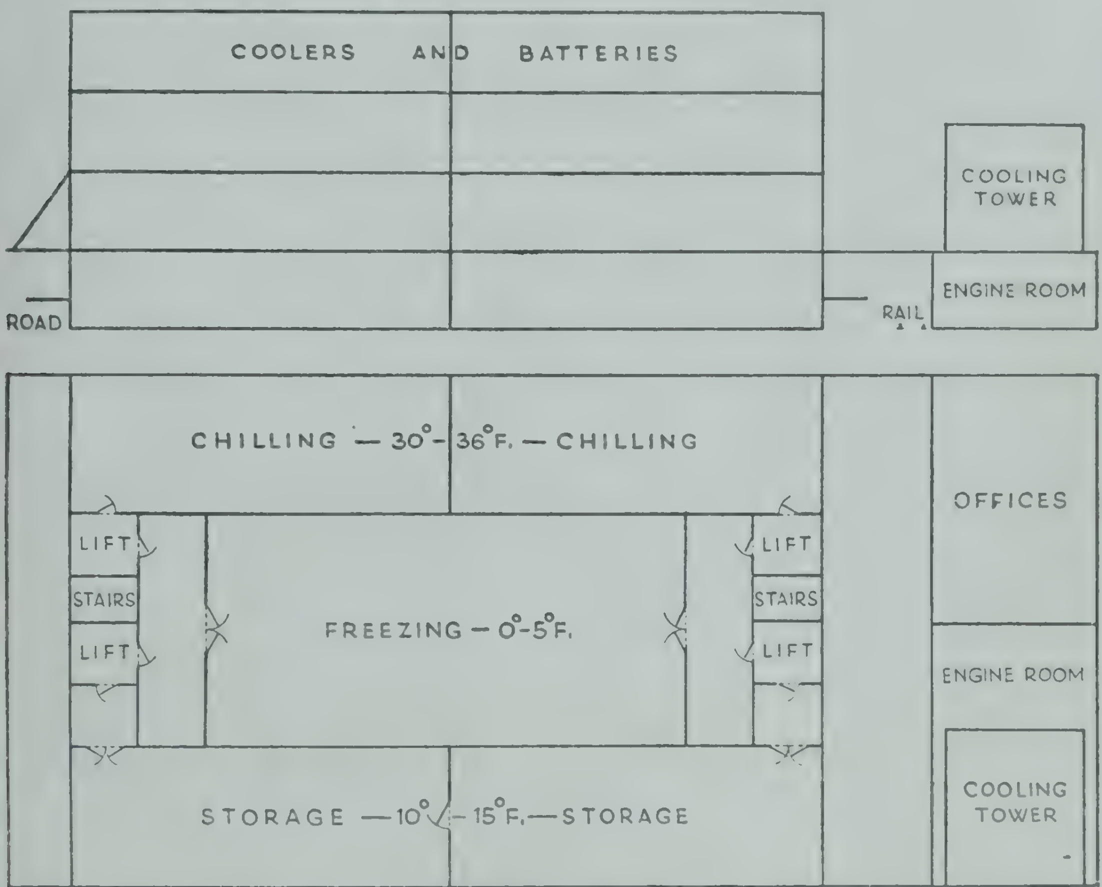
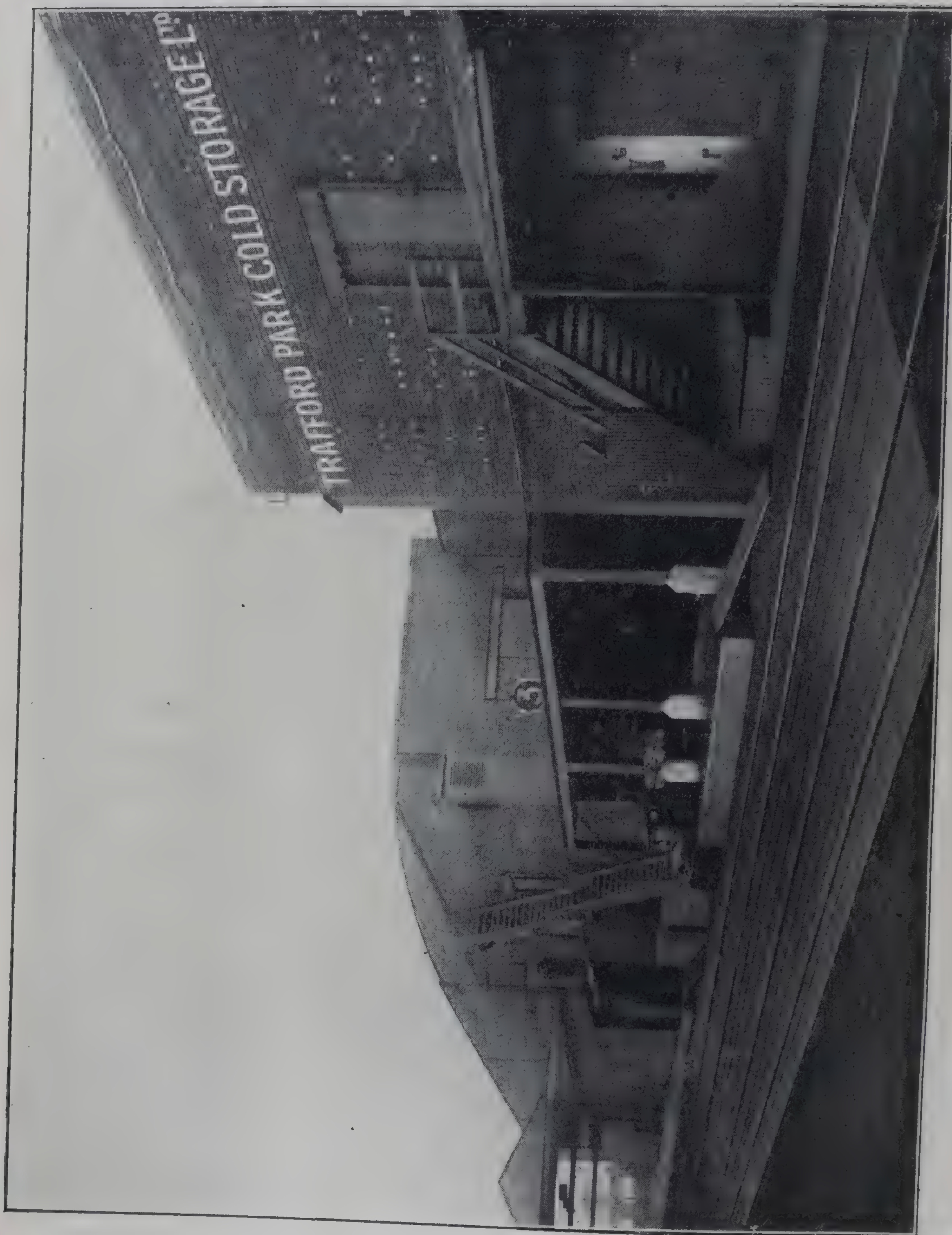


Fig. 2.—Alternative Chamber Lay-out.

A three-storey cold store, one hundred feet long, will be somewhat different in outside surface area from a six-floor cold store fifty feet in length. The roof area of the former will be double that of the latter. The sum of the wall areas of the latter will be more than that of the former.

Loading Bank

The Receiving and Delivering Deck has now to be considered. This is usually termed the Loading Bank. Location may prevent a double loading bank—one each side—although this is naturally desirable. The ideal aim is eight per cent. of total building area. That is, if the total cubic capacity of the


TRAFFORD PARK COLD STORAGE LTD

store is 500,000 cubic feet, then the total square foot area, if the chambers have not undue height, should be approximately 50,000 square feet, and the loading bank space should be eight per cent. of this, or about 4,000 square feet.

The movement in a store of 250,000 cubic feet would probably average 100 tons daily. On some days it may be greater—perhaps 75 tons being received, and 50 tons being delivered. There is need, therefore, for ample working space ; a long loading deck permitting the maximum number of railway waggons alongside, or, if there is not a private railway siding, allowing the maximum number of road lorries to be backed on to loading bank (which should be tail-board high—say 3 ft. 6 in.).

[*Courtesy*: *Wm. Douglas and Sons Ltd.*

Fig. 4.—View of a Loading Bank.

The loading platform is usually an extension of the ground floor level and 3 ft. 6 in. higher than street or yard level. The platform should be at least 18 ft. wide, and extend to the full length of the building—and usually beyond at each end, where location permits, each extension being at least as long as the loading bank width.

The loading bank will have a roof supported from the main building wall by tie-rods or brackets. This will facilitate the carrying on of work under all weathers. The loading bank will be free of columns. The whole length and width is primarily for trucks conveying goods from waggons and lorries to chambers via the lift shafts. Lift shafts should be built with cage entrances facing the loading bank—not, as is often the case, at right angles to the bank, thus necessitating unnecessary turns in the truck journeys.

One hundred tons daily movement means approximately ten to twelve railway waggons, or three times that number of motor vehicles. It also means about five hundred four-wheeled trucks, or double that number if two-wheeled trucks are used. As no cold store possesses such a stock of trucks, it follows

therefore, that with the average truck stock, each truck must accomplish at least ten journeys. That is, ten loadings and unloadings. Each hind or quarter of beef must be unloaded from the waggon, loaded on to the truck, and the truck pushed along the loading bank to the lift cage. The lift cage must start, ascend, stop, open ; the truck must be pushed from the lift cage through the air lock into the chamber. The beef must be unloaded from the truck, stacked into the stow correctly, and the truck, now empty, returned via chamber door, air lock, lift cage, and loading bank for another load.

Wise planning of loading banks is, therefore, of first importance.

General Construction

The building may be of brick, reinforced concrete, or concrete blocks. Reinforced concrete is the material that has won preference in recent years. It is, in most districts, the cheapest. A brick facing is often used in conjunction with reinforced concrete. Concrete blocks are sometimes adopted, and occasionally the cheaper panel. Concrete panels are liable to crack easily and are therefore not advisable.

It is usual for the construction to follow the curtain or envelope principle. That is, the outside walls are built independent of interior structure ; the floors, roof, and interior columns form a separate building. The insulation is fixed to the interior of the outside walls.

When the curtain wall principle is followed, provision of vertical expansion joints is made to allow for the unequal expansion and contraction.

Practice has proved that curtain wall construction is most economical and most efficient for prevention of heat inflow and consequent condensation. In the older type of insulation, sealing strips over wall and floor joints were always difficult to make thoroughly sound and efficient, and always proved a big loss of otherwise valuable storage space.

It should be appreciated that when a cold store is in operation, a big temperature difference between the inside and outside of the exterior walls is set up—as much as fifty and sixty degrees being the average difference. This is constantly " pulling " on the structure. The temperature difference sets up unequal stresses and strains, the outside brick wall moving one way, the insulation, floors and interior structure moving in another direction.

Usually the interior structure, being coldest, shrinks : the exterior expands. Where floor and wall insulation joins, the joints must be flexible in order to take up this movement. Otherwise cracks develop, with consequent heat inflow, and resultant deposit of condensation which grows into large icicles, and goods stored near these cracks soon have a mould deposit. This, if not checked, grows rapidly, affecting all the goods in the chamber, causing large losses and earning the store a reputation which will eventually ruin the business.

Curtain wall or envelope insulation construction offsets these difficulties. With it, the internal and external structures move freely in relationship to each other, and cracks and heat inflow are seldom experienced.

Insulating Materials

The best heat insulator is a vacuum. The next best is a gas in a completely motionless state. For cold stores and refrigerators neither the vacuum nor the motionless gas is practicable. Solid insulating materials are therefore necessary.

One of the early forms of insulation was the provision of a 2 in. air space, but any air space has convection currents circulating within it, and convection currents increase the transmission of heat.

Insulating materials sub-divide the air space into minute cells, thus reducing the convection currents and the transmission of heat. Heat transmission is also reduced by preventing radiation, and if the insulating material between the cold and hot surfaces is close grained, and the material is of a nature which is known as a poor conductor, then transmission by conduction is also reduced.

Refrigeration, when defined, is the removal of heat from any given space, and also the prevention of its return. Insulation is the means used to limit the inward or return flow of heat. Heat transmission through insulating materials such as wood wool is low compared with, say, tin or iron. Thus a material can have high or low rate of heat flow or, as it is more easily known, thermal conductivity.

Thermal conductivity is the quantity of heat, measured in British Thermal Units, which flows per square foot per hour through one inch thickness of the material for a difference of temperature of 1° Fahr. between the two sides.

Thermal conductivities of metals are related to the electrical conductivities so that it follows that any bad electrical conductor is equally a bad thermal conductor. Glass wool affords an example of this relationship and can be used as an insulating material.

It might be as well to say here that the thermal conductivity expressed in gram calories per second per square centimetre and for one centimetre thickness for one degree Centigrade difference in temperature is $\frac{1}{2903}$ times its value expressed in B.T.U.'s.

Varieties of insulating materials are many, and experiments are continually being made with the object of discovering a still more efficient, cheaper, and more easily obtained material. All materials are, however, objectionable in one or more respects, but slab cork has so far remained the supreme and most popular insulator.

A good insulating material must have low thermal conductivity, and no tendency to absorb moisture.

Moisture absorption is induced by capillary attraction, and also by transmission due to an applied force such as wind pressure or water suspension in air. Moisture can be in either a liquid or gaseous state, and an increase of moisture decreases the insulating value of any material.

Charcoal, for example, has excellent insulating qualities, but its affinity for moisture is such that, as an insulator, it is now little used. Affinity for moisture implies, that in order to absorb the moisture, the material must displace its entrapped air. Absence of air cells increases thermal conductivity,

and thus increases heat transmission. Charcoal, therefore, if used in a cold store as an insulator may at first, or shortly after erection, have a high percentage of insulating efficiency. Deterioration, however, would set in rapidly, and not only would the refrigeration load on the compressors increase, but the absorbed moisture in the insulating material would affect the building construction by causing corrosion or rotting of timber frames.

Even cork, although in itself impervious to moisture and free from capillary attraction, will hold moisture in the spaces between the granules if, due to cracks in floors or other causes, water is allowed to leak through to it. For this reason it is always necessary to damp-proof all walls and floors before proceeding with insulation.

In practice all insulating materials have sooner or later revealed defects. In the laboratory, tests for thermal conductivity are made by measuring the temperature difference between opposite sides of insulating material when one side is subjected to heat from an electrically heated plate.

Immersing the material in water for stated periods, and measuring the differences in weight, gives an indication of the percentage increase in moisture content.

√The requirements of an insulating material are usually listed as follows :— It must be odourless, and powerless to taint perishable goods, it must be free from moisture, and must not ferment under damp conditions. It must be vermin proof, light in weight, waterproof, fire-proof, and must be easy to instal from the practical angle.

The materials which have been tried as insulators at one time or another are many and varied, and include tree fibre from various trees, cardboard cellular bricks, diatomaceous earth and brick, slagwool, rubber in sheet and cellular form, and all known varieties of wood, including balsa wood, and wood fibre.

Slab cork is manufactured from high-grade raw cork. This, cut into assorted sizes, is steam compressed in moulds, under pressure, something like ten tons per square foot, and gradually heated up to 500° Fahr.

By this heating under pressure and gradual cooling afterwards, the natural gum in the raw cork cements the cut pieces or granules together. The pressure, baking, and cementing, thus forms a composite mass of minute air cells which gives a low thermal conductivity. The grade of the raw material and the density of the product affects the thermal conductivity, but cork manufacture of the present day is such that a high standard has been attained, and 0·30 B.T.U. per square foot per inch thickness per degree difference in temperature is the average measurement of conductivity.

There is slab cork on the market known as unbaked. This is manufactured by cementing the granules together with various adhesive materials. With the unbaked slabs the absorption of moisture is higher, and thermal conductivity therefore not so constant. The lighter the slab cork, the lower the thermal conductivity, so that weight per cubic foot is important.

Average weight for good quality slab cork is 10 lb. per cubic foot.

Granulated cork can be obtained in various degrees of granulation. The smaller it is the better. It is usually sold in two grades—coarse and fine.

Granulated cork allows convection currents which affect the thermal conductivity. Being loose material it is liable to settle, leave empty spaces in the insulator walls, and is prone to absorb moisture.

Slag wool, otherwise silicate cotton, is a fibrous material which can be easily compressed. The closer it is packed the better it will be for thermal conductivity. Packing so close that the weight of material approximates 10 lb. per cubic foot, the thermal conductivity approaches that of good quality slab cork. Its principal disadvantage is liability to indifferent and loose packing.

Charcoal. The high percentage of moisture absorption possessed by charcoal has been the cause of its discontinuance as an insulating material. In the early days of cold store practice it was widely used. When new and dry, its insulating properties are good.

Rubber. Cellular expanded rubber, rubber sponge, and other forms of rubber material possess fairly low conductivity, but disadvantages in connection with application, repairs, and so on, prevent it from being widely adopted in cold store construction.

Timber has a conductivity about three times as high as that of cork. Balsa wood is an exception. Its thermal conductivity is comparable with that of the better types of insulators. Its capacity for absorbing moisture, however, is high, and it is easily damaged.

Earth, straw, pumice, sawdust, have insulating properties but absorb moisture and must be continually re-packed. Rice husks have also been used but moisture absorption and settling are decided disadvantages. Such materials are not vermin proof.

Saturated material is useless for insulation. All insulation, therefore, must be sealed. Deterioration will result sooner or later, when sealing is imperfect and moisture infiltration is not checked. The effect of moisture on thermal conductivity results in decreased density of the insulating material, and consequent increased conductivity.

It may be summarised, therefore, that the chief insulating materials are slab cork and slag wool. The others are considered only when neither cork nor slag wool is available. Various plastics are making their appearance as insulators but baked slab cork is still the only insulant which, when properly applied and correctly erected, will practically set at rest any future fears of insulation troubles.

In considering any insulation material it is necessary to gauge correctly

(1) Its thermal conductivity
(2) Its capacity for moisture absorption
(3) Its ease of application and erection.

Cost is unimportant until these three properties are correctly assessed.

EQUIPMENT

The essential equipment of cold stores is first, the refrigerating machinery ; second, lifts and elevating apparatus ; third, handling equipment ; and fourth, recording instruments.

Refrigerating machinery and cooling plants are outside the scope of this book. Lifts and handling equipment are necessary, but in most cold stores the equipment is of the most simple design. Recording instruments are confined to scales, thermometers and hygrometers.

Cranes

Few cold stores are equipped with cranes on the loading banks. They are not always necessary except with certain commodities such as box bacon. Rail vans and road vehicles are unloaded by man power fairly easily. Occasionally where the design of the loading bank makes it necessary, a small crane can be used with advantage. Such cranes are usually of the overhead electric type. An ideal crane for use on a loading bank is a portable or stationary crane—it can be either—with a jib that can be swung round in a complete circle without moving the base. It has a combined electric hydraulic action, very simple to operate, and with a high percentage of safety. The crane is fitted with safety valves which automatically operate whenever an overload is attempted.

Operation of this type of crane is simply a matter of a switch and lever moved to either " up " or " down " positions. Slewing of the jib is accomplished by means of hand wheels.

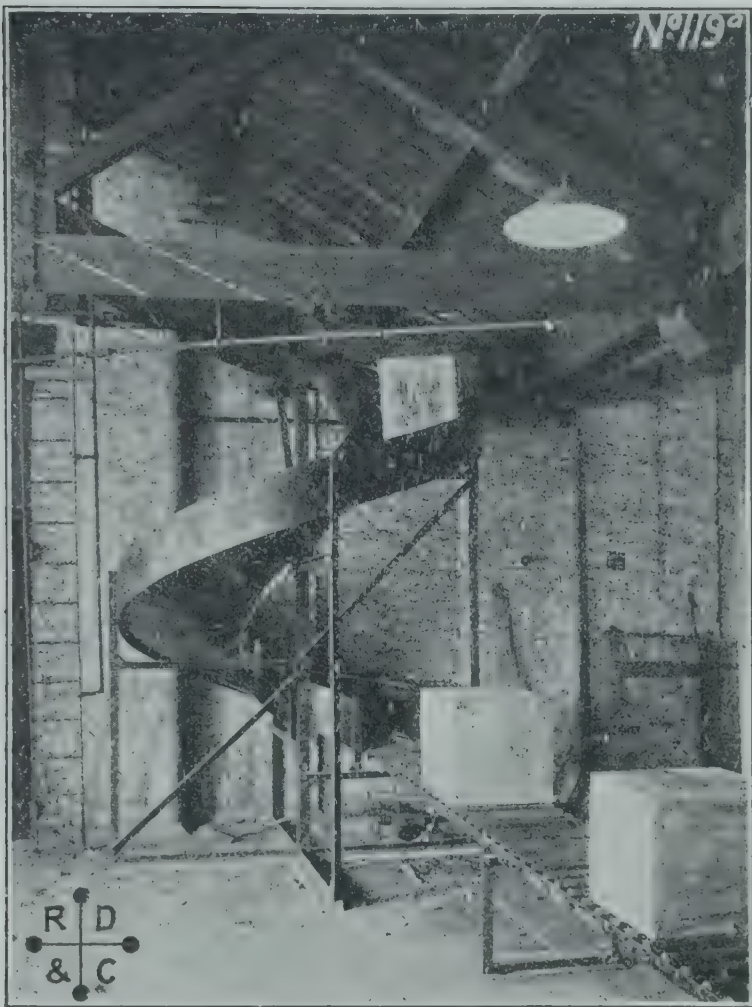
It is a nine hundredweight crane with a maximum lift of ten feet. It has a jib radius of 3 ft. 6 in. and is driven by a 3 h.p. motor. The speed of the lift is 40 feet per minute.

Lifts and Conveyors

The best lifts for cold store work have been proved to be hydraulic, but only the older cold stores have these. The regulations enforced by the Factory Act make it compulsory for cages and lift openings to have gates, and all gates must be electrically controlled, so that while the lift cage is in motion it will be impossible to open the gates, and while the gates are open it will be impossible to set the cage in motion.

Gates and controls increase the number of possible breakdowns and stoppages, and the physical effort necessary to open and close the usual form of sliding lattice gate can be considerable when multiplied continuously throughout the day.

It is necessary therefore so to design cold store lifts that they will be trouble free, simple to operate, absolutely reliable, speedy, and yet consistent with the requirements of the Factory Act. The cage should be of the correct dimensions, neither too big nor too small. The correct size of lift cage should accommodate two trucks only. Gates should not require great effort to open or close.



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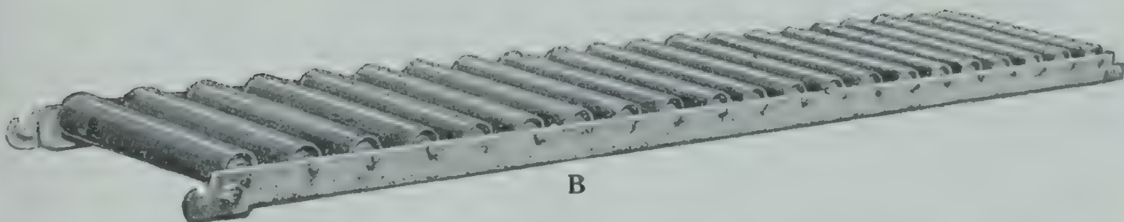

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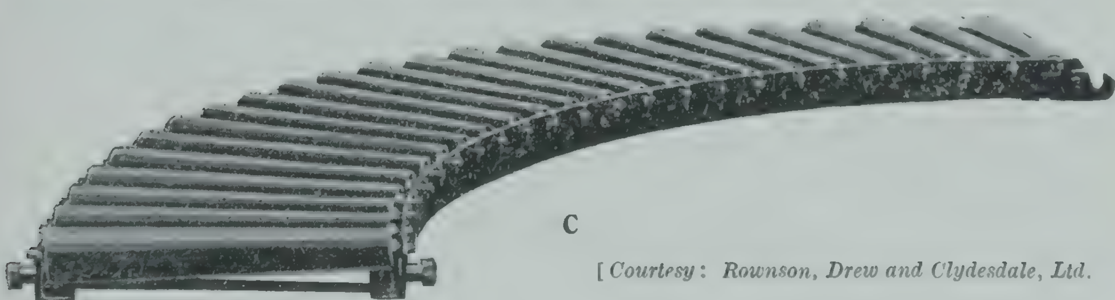

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[*Courtesy*: *Rownson, Drew and Clydesdale, Ltd.*

Fig. 5.—Gravity Roller Conveyor.

A shows a typical installation, B and C show the construction of straight and curved sections.

A gravity roller conveyor is another useful installation. It will supplement the lift and prove invaluable for moving small cases from upper floors to the loading bank.

Trucks

Trucks are such an important and necessary item of equipment that they are described separately (see page 38).

Recording Instruments

Scales.—Cold store scales are usually built into the loading bank floor so that the cold store truck can run on to the platform. The checker must read the gross weight of the truck and the load combined. The checker's manipulation of the scale, his reading of the weights shown, and his totalling on the delivery slip must be quick and accurate. The older cold stores have the older type scales from which all readings must be taken from the scale bar. The newer cold stores have the more modern dial reading scale, and these scales are the only really suitable scales. There should be twice as many scales as there are complete striking and stacking gangs. For example, if a cold store has sufficient staff and loading bank space to work three vehicles simultaneously, then three checkers are necessary. A checker can only work one scale at once, but he should have a reserve scale so that six scales are necessary.

Thermometers.—Thermometer equipment requires particular consideration. Special notes are given later on thermometers and other instruments (see page 148).

Lighting

Refrigerated chambers must, of necessity, be equipped with artificial light. Insufficient lighting has many disadvantages. Good lighting facilitates good stowing, ensures cleanliness, and makes for easy reading of marks, etc., on packages. On the other hand every extra light means so much extra heat, and heat in cold store chambers must be avoided, and can always be regarded as an operating loss. The usual practice is to have as many lighting circuits as are necessary, each with its separate control switch. Lighting can then be concentrated in that part of the chamber where it is required, leaving the rest of the chamber in darkness.

CYCLE OF OPERATION

Cold storage operation is mainly the receiving and delivering of goods. The goods are foodstuffs—principally meats, dairy produce, fish, fruit, and vegetables. Compared with dry warehousing or the storage of non-perishable articles, cold storage is specialised work, and operation of a cold storage warehouse is therefore technical, calling for special knowledge.

Because of the perishable nature of the commodities handled, the cycle of operation cannot be interrupted. Once started, it must be completed. The entrance into the warehouse cannot remain open, and it is not only expedient but extremely necessary that the cycle of operation—either receiving or delivering—must be carried through at top speed. Any delay means loss of money, increase in thermal losses, increase in handling costs, and increase in possibility of damage and deterioration to goods.

Any cold store design should provide for easy operation. A spacious entrance to the cold store building is necessary, first of all. Unfortunately, a great many stores are situated in the older, built-up parts of the towns and cities, and vehicles going to and coming from the cold store, must of necessity thread their way through a labyrinth of small, narrow back streets.

The yard or grounds of the cold store should be wide and extensive enough to accommodate several lorries and trailers at one time. There should be a broad, unencumbered loading bank, and easy entrances to lifts.

The ideal shape for a cold store would be circular with a corresponding circular loading bank, and with lifts at the four compass points, North, South, East, and West. The loading banks would be wide, free of columns, and with a canopy roof covering not only the loading bank, but also the rail wagon or motor lorry alongside.

The correct position for lifts at cold stores never seems to have been determined. Obviously, the correct position must be that which is nearest to the chambers and to the loading bank, so that the run of the trucks from loading bank into lift, and from lift into chamber, is as straight as possible, and involves the fewest turns of the truck.

If a store is receiving, for example, one hundred tons of lamb carcases, at 67 carcases per ton, and these carcases are loaded on to cold store trucks at 20 carcases per truck, this means 335 truck journeys from loading bank into chamber. Even on well-designed loading banks, that would mean 1,340 right-angled turns of the truck. In the average type of store, it usually means far more. Even with the modern ball-bearing cold store truck, a tremendous amount of physical effort must be expended to turn and push a truck loaded with 20 lambs 1,340 times in an ordinary working day. Such a truck represents a gross weight of 936 lb.

It will be seen, therefore, that right from the beginning, the design and the planning of the premises have an important bearing on the operation of the cold store.

A store handling one hundred tons of mixed commodities daily, will have a considerable number of checking slips, weight notes, and delivery advices. One ton might easily involve twenty or more different advices. Twenty different delivery orders may involve twenty different vehicles. This is extreme, but it is possible.

One hundred tons a day means that two hundred tons are handled, because every ton will have to be handled twice. Loading from stack in chamber to

cold store truck, and from truck to motor vehicle, if handling deliveries, and *vice versa* if handling intakes.

The number of men on a stores staff handling a hundred tons daily should be not less than fourteen. Two "striking" gangs of three men each for unloading from rail vans or motor vehicles on to cold store trucks; two men to push the trucks along the loading bank into the lifts; and, in each chamber, a "stacking" gang of four to six men.

With such a staff, unloading from wagons or lorries, trucking to and stacking in chambers would be continuous. Delivery from chambers would also proceed in a steady rhythm. Any less staff immediately has three effects: one—the rhythm is broken and the speed per hour decreased; two—the stacking in chambers is indifferent and not nearly high enough; and three—the men tire more easily.

Efficiency, continuity, and speed of movement are dependent on the requisite number of gangs, and the requisite number of men in each gang. One man short can upset the balance of a cold store staff.

With the requisite staff strength, the smaller store can usually show a higher tonnage speed per hour than the larger store. The average tonnage speed per hour at stores of 250,000 cubic feet capacity works out at half a ton per man, although this can, of course, often be exceeded. In the smaller store it is higher. There are two obvious reasons for the higher speed at the smaller store. First, the tonnage speed is governed by three main factors: (1) Design of store and facilities for handling goods; (2) Relationship of situation of lifts to loading banks and chambers; (3) Organisation of staff. Second, at the smaller stores, the distance from loading bank to chambers is not so great, and the smaller staff usually works more willingly, and exhibits a better team spirit.

Tonnage speed, however, will vary considerably according to proportion of intakes to deliveries, and with the varieties of commodities handled.

The work of a cold store is invariably either a "feast or a famine." Work cannot be spaced out or regulated; there are very busy days, and very slack days.

The effect of trying to operate a cold store with too little labour soon shows itself in wasted insulated space. Bad stowing is invariably the result, and untidy chambers, soft meats, sticky stacks, the spread of mould, and mixed-up commodities become the rule rather than the exception.

STAFFING

On the staff of any cold store there are three important men:—the manager, the engineer, and the foreman. The manager to manage and carry the responsibility, the engineer to supply and maintain the refrigeration, the superintendent (foreman) to organise and control the warehousing staff. The checker and chief clerk are not executive or administrative staff, but they do

represent the key men of the organisation of any cold store. Without good, conscientious, experienced men in these positions the cold store operation will be poor. The checker is equally as important as the chief clerk.

The Manager

The manager of any cold store, large or small, with a straight warehousing business, or a business of a composite nature, must be a business man, a factory manager, an engineer, and an accountant. When everything is going well, he should be a confirmed pessimist. When business is bad, and plant operation worse, he must be a supreme optimist. When things are at their best he should be prepared for the worst.

Adaptability, confidence, endurance, and resourcefulness are very necessary. He should have the power to promote, develop, and encourage loyalty and reliability on the part of his staff. He should possess the gift of extracting every ounce of effort from the personnel under his management. He should have a flair for organisation, advertisement, and method. In short, a cold store manager must be everything in one. The word " can't " should not be in his vocabulary.

He should be able to convince his engineer that good temperatures are always necessary, but that obtaining them incurs operation of machinery and this costs money. Equally, he must be capable of assuring his foreman that only correct stowage and economical handling of labour will earn a good reputation and profits for the store. He must appreciate and anticipate the difficulties that will be met, and yet at all times must ensure that he will have good temperatures, low running costs, correct stowage, and a low cost handling charge, *i.e.*, low handling costs per ton of goods moved.

The mysteries of an engine room, and the peculiarities of the refrigerating compressor should be simplicity itself to a cold store manager. He should therefore be on familiar terms with the principles of mechanics, the properties of fluids and gases, the laws of thermodynamics, the principles of refrigeration, the theory behind the refrigerating cycle, and the design and construction of refrigerating plant and equipment.

The advantages and disadvantages of different refrigerating systems, and the design and construction of cold stores as developed by latest cold store practice, should be perfectly understood by any cold store manager. He should know exactly the class of storage for which his store is most suited.

He should know everything there is to know about meats, fruits, and dairy produce, because these represent the main commodities he will be called on to handle. Practically every known form of food is now being handled by cold stores. As can be imagined, this calls for very wide knowledge and experience.

He should be able to impart some of this extensive knowledge to the key men on his staff, and every cold store operator should aspire to acquiring as much as possible of this encyclopædic information.

The Warehouseman

Cold storage warehousemen, or deck staff, as they are occasionally known, are recruited from every type of labour. The number necessary depends on the size and design of store, the equipment available, the class of goods handled, and various other factors. Fourteen men for a hundred tons total daily movement is a minimum strength for deck staff. Dependent on local conditions, the average store usually has a small number of so-called permanent staff. The rest are made up from casual labour or labour that is being constantly turned over. Employment of extra deck labour is necessary only when heavy shipments are being received or delivered. Few cold stores can depend on regular movement of goods.

There are two capacities to a store: the storage capacity (the number of cubic feet of insulated space) which, when divided by the number of cubic feet occupied by each ton of goods stored, will give the tonnage capacity of the store; and the daily handling or movement capacity which is usually one-thirtieth of its tonnage storage capacity and is governed by a number of factors. As an example, a 100,000 cubic feet store, or a 1,000-ton capacity store catering for mixed refrigerated goods, with a loading bank length sufficient to accommodate and allow for simultaneous handling of four rail wagons and three motor lorries, would require a labour strength of at least seven gangs. But such simultaneous handling would not be possible for a number of reasons. On the other hand, a loading bank accommodation for this number of vehicles would, nevertheless, be desirable. Sufficient labour would, however, be necessary to handle at least two vehicles at once, one intake, and one delivery. These would be divided into two "striking" gangs to unload or load the vehicles on the loading bank, two stacking gangs, and truckers. The striking gangs would consist of three men each, the stacking gangs of four men each, the truckers would be two to each striking gang. For each vehicle a checker would be required. Altogether twenty men would be engaged, and so long as perfect rhythm was maintained, a speed of ten tons per hour could be achieved. With such a staff, unloading of vehicles, trucking to, and stacking in chambers would be continuous. Breaking down the stack in chambers, trucking from, and loading into the waiting vehicle would also make the deliveries continuous, and each checker would be busily engaged.

Providing that the checkers thoroughly understand their work, and can tell at a glance the different descriptions of the commodities and the packs that are being handled; providing that they are absolutely reliable men, are familiar enough with a weighing machine to obtain an exact weight with a mere touch, and are quick and sure at figures; and providing that the foreman can depend on his chamber men, and is capable of keeping his men going and extracting the last ounce of endeavour; then such a staff should be able easily to attain over one hundred tons a day movement, and be sure that no mistakes have occurred, and that all stacking work will be correct.

ANALYSIS OF HANDLING WORK

Let us take, for example, a three-storey cube-shaped building with a loading bank on the ground floor, and lift shafts at each end. The total capacity of this store is 4,500 tons. The chambers are fifteen in number, of varying dimensions, but with a total number of cubic feet of insulated space amounting to 450,000. The daily movement approximates one hundred and fifty tons. The staff consists of twenty-one men, under the direct supervision of the foreman. The foreman has so organised his labour strength that the oldest and youngest attend to trucks and lifts, the strongest and most knowledgeable form the stacking gangs, and the rest are strikers. The staff is divided into :—

2 Checkers.
2 Charge-hands or Chamber men.
2 Lift men.
15 Stacking and Striking men.

The fifteen warehousemen would be sub-divided into gangs for striking and stacking work, the number of each gang varying with the commodity handled. Generally, six men will be kept fully occupied, stacking or stowing inside the chambers, to three men striking on the loading bank. But if handling butter or cased goods, six men may be found too many. On the other hand, if handling bale bacon the striking gangs will always beat the stacking gangs. Bale bacon is a heavy, awkward commodity, and demands from the stacking gang considerable strength.

Handling Intakes

In handling intakes from either road or rail transport, three men unload from the transport wagon on to the cold store trucks. The truck man will push the truck, after it has been inspected and checked by the checker, along the loading bank to the lift, returning with the empty truck. The lift man will raise the lift to the chamber floor level, and run the truck into the chamber. The stacking gang will unload the truck and push the empty back to the lift gate.

A railway wagon containing 80 quarters of bone-in-beef, 150 quarters of boneless beef, or 300 lamb carcases, will necessitate, for unloading and stowing in chambers, at least ten men. Less men can complete the unloading, of course, but the time taken will be much longer. Fifteen cold store trucks will be employed. The time taken should be not more than 40 minutes at the most. The tonnage will equal seven tons, if beef, four tons, if lambs.

Deliveries by rail, where cold stores are provided with rail sidings, will necessitate employing the same number of men because the rail vans are usually loaded by the cold storage staff. Deliveries by road involve bringing cold store trucks only to the tail-board of the lorry. The lorry drivers unload the cold store trucks and load their own lorries. Cold storage staff only assist in stacking on the lorries when assistance is requested and, usually, the cold store can make a charge for this assistance.

Where cold stores are not provided with rail sidings, but deliveries for rail transport are made by loading railway-owned motor lorries or horse-drawn carts, the drivers stack their own lorries, the same rules applying as for road transport.

Analysis of Daily Movement

Analysis of a daily movement of, say, 150 tons may show that the day's tonnage has consisted of 80 tons of intakes, and 70 tons of deliveries, made up as follows :—

	In	Out
Meats	40 tons	30 tons
Bacon	30 tons	20 tons
Butter	10 tons	20 tons

Of the 80 tons intakes—50 tons were received by rail, and 30 tons by road.

Of the 70 tons deliveries—60 tons were sent by road lorries and 10 tons were loaded on to rail.

The number of men on the staff would be nineteen, and in addition there would be two checkers. The tonnage for the day, therefore, would be 150, or 20 tons per hour, which works out at approximately 1·1 tons per man per hour.

Handling Capacity of a Store

Handling capacity of a store is usually expressed as decimal tonnage per man per hour, or total tonnage of combined staff per usual working day of eight hours.

Tonnage rate per man hour bears a definite relationship to the weekly wage bill, and therefore to handling costs per ton. Handling costs are one of the most important items in the expenditure of any cold store. It is evident, therefore, how important is tonnage speed and how necessary it is that the cause of any hold-up in handling should be enquired into, cured, and repetition prevented.

Intakes of 50 tons by rail represent the unloading of eight to ten rail vans, and 30 tons by road averages seven to nine lorries.

Deliveries of ten tons by rail would mean the loading of at least two rail vans, and 60 tons by road approximates fifteen full motor lorry loads.

The important point to remember is that each vehicle loaded or unloaded means a separate checker's note—either receipt or delivery. If more than one vehicle is worked at the same time, this will involve a separate checker, a separate scale, independent trucks, and independent loading bank space.

The speed of intakes will vary with class of goods. For lamb carcases or cased goods such as butter, the speed is high, the trucks are easily loaded and unloaded, and checking is not difficult. Stacking is also easily done, the stacks being formed with simple regular movements, both carcases and cases sitting

together compactly. Bags of hearts, offals, veal, and boneless meats are awkward to stack, consequently the speed of handling is slow. Bale bacon is heavy, and requires more labour.

It should be understood that in calculating handling speeds, the "tons per man hour" expressions refer to operative labour only. Checkers, foremen, chambermen should not be counted as operative labour. Stacking and striking gangs and truckmen only should be regarded as forming the operative strength.

CHAPTER 2

HANDLING AT THE SMALLER STORE

VARIATION IN CAPACITY OF STORES

Cold stores in this country vary considerably in size. There are a few large stores of over a million cubic feet capacity, others of varying figures down to as small as 10,000 cubic feet. It can be appreciated, therefore, that a number of different problems of handling are to be met in stores, varying with the capacity of the store. Generally speaking, and as has been mentioned previously, the faults of layout and design which make efficient handling difficult are more glaring in the small cold store. Loading platforms are too small, lift capacity is inadequate, and the situation of chambers and of the entrances to them, in relation to the loading platform, are hopelessly wrong.

The existence of these faults is due to many causes. Of the many cold stores to be seen very few were originally designed and constructed as such. Most of them are converted buildings which were originally designed for a purpose far different. One of the oldest cold stores in England was once a theatre.

Many of the smaller stores are situated away from docks and railway termini, and are usually in the centre of the town, under markets, or adjacent to them. Entrances are usually small, congested, and difficult. There is little yard space, and two lorries or carts completely block what entrance space there is. Practically none has rail sidings, and intake from rail transport is of necessity from railway lorries and carts. Handling is, therefore, a slow business and handling costs comparatively very high.

Modern cold store practice and construction will tend to prevent repetition of these rather obvious mistakes. Rectification of faults, when possible, is a costly business, and involves re-construction. Re-construction means capital outlay. The proprietor of a small cold store is usually not in a position to afford capital outlay. Capital cannot be borrowed without justification and security. Justification would be proved only after a close analysis of handling costs.

STAFF EFFICIENCY

The efficiency of the staff as a whole, and individually, is usually much higher at the small cold store. At the larger store the deck staff will, if analysed, be found to have at least one man, and probably more, redundant. In other words, there will be some members of the staff shirking. The greater the number of men, and the larger the team, the more opportunity there is for men to slip away, to dodge their share of the work. The man at the small cold

store has no such opportunity. He has to be constantly within call. And generally, he is more reliable, more efficient, more interested, and more " cold store minded."

The just reward for service in a small cold store would be transfer to a large cold store. The large cold store would gain a man of all-round experience, and the transferee would, for the first time, have in comparison an easier job.

Casual labour and a constant turning over of labour has always been a feature of cold storage work in the larger capacity stores. In fact, large cold stores depend mainly on casual labour. They cannot afford to maintain a full complement of deck staff on idle days or days when there is little movement. Labour is engaged only when shipments are expected. The permanent staff of a large cold store seldom represents more than ten per cent. of its actual labour costs.

With the small cold store, casual labour is seldom engaged. On days of heavy intakes or deliveries, the whole staff, including the manager and engineer, doff coats and work on the loading bank.

Many of the smaller establishments are entirely basement stores. From the point of view of operating costs, basement chambers are advantageous, in that they cost less to maintain at a desired temperature. But handling charges are higher, because all goods in and out must be conveyed by lifts. Tonnage speed is slower, because of cold store design, and greater effort is required from the staff, because of the lesser number of men.

TRAVEL OF COLD STORAGE TRUCKS

As a point of interest, an ordinary bicycle cyclometer was once fitted to the axle of a cold store truck at a large store, and kept there for three days. During that time the store handled six hundred tons. The cyclometer was then removed and fitted to a cold store truck at a town store of one-quarter the capacity. It was allowed to remain fitted for two weeks, during which time the small store handled four hundred tons. During the three days, and the fortnight, respectively, each truck at each store was in constant use throughout the eight-hour working day. The results were rather astonishing. The truck at the smaller store, although used more frequently and for a much longer period, registered less than fifty per cent. of the distance covered by the truck at the larger store. The same results could have been arrived at by working out the distance traversed by each truck from loading bank to chamber. The cyclometer saved the trouble of calculations on paper and illustrated clearly that in judging handling speed and handling costs, the design and construction of the store has an important bearing.

Factors governing handling speeds and costs can be set down as follows :—

(i) Distance from centre of loading bank to lift.

(ii) Time taken for travel of lift.

(iii) Distance from lift gates to centre of chamber.

CLASS OF LABOUR

The type of labour attracted to cold storage warehousing tends to grow worse. It differs considerably in different districts. The effect on operation, and thus the handling costs, when the older type warehouseman is replaced by the present indifferent type, can be imagined. Indeed, the problem is becoming so serious that many cold store proprietors are beginning to look with interest at the various mechanical handling devices which are such a feature of ordinary warehouse work. Cold storage warehousing, however, prevents in many ways the use of mechanical handling apparatus. Certain apparatus, however, can be used ; conveyors, and stacking machines, and transporter trucks, for example. Cold store personnel must be, of necessity, the right type. The cold store industry depends to a large extent on physical strength—physical strength and endurance. And just as a wall or an iron girder is only as strong as its weakest point, so a stacking gang working inside a cold chamber is only as strong as the weakest member of that gang. It is essential, therefore, that a cold store foreman should pick his gangs with discretion and judgment. And every warehouseman should realise that, as in perhaps no other industry, when intakes or deliveries are being handled in the cold store, the work should be at top speed. There is little time for rest, and no excuse whatever for going slow. When cleaning or ordinary maintenance work is being done, pressure can be eased a little. But the day's tonnage must be handled as fast as possible, and calls for the last ounce of effort.

CLASSES OF GOODS AND COMMODITIES

If boneless beef is being handled, checking slows down the speed of loading or unloading. Hessian wrapper marks must be examined in order to get full particulars of the class of beef being received. The beef itself must be examined to ensure that any doubtful or soft quarters are separated before stacking.

The speed of intakes will vary with class of goods. The speed of deliveries will vary even more, because of the need for taking marks and weighing out.

If it is beef with bone in, in addition to the extra checking required, the quarters are larger and more awkward to handle. Stacking is more difficult. Experienced labour will attain a greater speed than inexperienced labour. There is a limit to the speed, beyond which it is not possible to go.

If pork sides or carcases are being handled, the loading of trucks and stacking in chambers is much easier, in comparison with beef. Checking is slower, because of the necessary classifications to be made and the separation of weight range required.

Bacon, whether in boxes or bales, can be moved only slowly, because of its comparatively great and dead weight. The awkward shape also tends to make handling difficult. The considerable number of marks and detailed readings that the checker must take, tends to slow down the speed of movement.

SUMMARY

Of the general points that contribute to speedy handling, the first is organisation of staff. Warehousemen should be so apportioned that striking, trucking, and stacking are co-ordinated perfectly, and a perfect rhythm is maintained always. If the number of staff permits the practice, handle more than one vehicle at the same time. It is fairly easy to calculate the tonnage that is being handled each hour. A foreman who knows his work can very readily convert a number of quarters of beef into tons, and if the tonnage for any one hour shows a considerable drop, he should be able at once to put his finger on the cause of the hold up, and remove it immediately.

It should be appreciated that whether the chambers are full or empty will affect the speed of intakes. If a chamber is only half full the stacking gangs will be able to unload trucks as fast as they are brought into the chambers. If a chamber is nearly full there will not be sufficient room for the stacking gang to work with freedom, and trucks are apt to build up.

Speedy handling is useless if the various phases of the handling are done carelessly, and the work must perforce be done again. Re-handling adds to handling costs, and is, of course, an indication of inefficiency.

Elementary Rules

There are certain elementary rules that the cold store warehouseman must never forget:—

(i) Lost space means loss of revenue.

(ii) Too tight stowage of any class of goods interferes with correct air circulation.

(iii) Goods should be stowed so that stacks can be checked, and withdrawals made from stacks—at the rear of the chamber, if necessary, as easily as from the front.

(iv) Goods should be stowed with due regard to correct separations. Where the chambers are large, it is probable that several varieties of refrigerated commodities will be stowed. It will be necessary, also, to have separations for goods similar in description, but arriving on different dates.

(v) Frozen goods arriving in soft condition should not be stacked immediately but should be laid out separately for hardening. Any goods which have deteriorated slightly should not be mixed with goods in better condition.

(vi) In chill rooms, great care must be taken that goods of one class, such as citrus fruits, are not mixed with goods of high absorbency, such as eggs. Chill room goods necessitate greater separation of stacks and larger air spaces. A most careful watch must be kept for mould growth.

Excessive opening of doors, indifferent stacking, fluctuating temperatures, and the mixing of wrong goods all bring evils. These develop trouble sooner or later, and make re-handling necessary.

The cost of handling is primarily a question of efficient staff organisation, and a full effort from every member. Loading into and unloading from

chambers, if performed dilatorily or unwillingly, will affect plant operating cost, in that doors will be left open too long, chamber temperature rise will be unduly rapid, and the restoration of normal temperature will cause extra running hours for plant.

Five shillings per ton is an average cost for handling, but this can be, and is, reduced if due regard to choice of equipment is given, and if the stores foreman thoroughly understands his work, and there is no unnecessary waste of time. Very often, because of errors in judgment, or lack of foresight, or badly designed chambers, the double handling of goods is required, such as transfers from one chamber to another, re-stacking, and so on.

In a well-organised store with modern equipment the handling charges should never exceed five shillings, and on good days can be reduced to as low as 2s. 9d. per ton.

CHAPTER 3

CHECKING

DUTIES OF THE CHECKER

THE checker is an important man on any cold store staff. The cycle of operation begins and ends with him. Mistakes may or may not begin with him—they very often do, however—but he is the one man on the staff who can discover that mistake and prevent it from getting outside the store.

The reputation of a store is, to a large extent, dependent on the checker. Loyalty and conscientiousness should be among his main qualifications. An indifferent checker means an indifferent store.

The whole system of cold stores book-keeping records commences with the checker's receiving slip on the loading bank. This will show the customer's name, the full description of the goods received, the date, the time unloading commenced and the time it was finished, how the goods were brought to the store, whether by rail, van, or lorry, with particulars of conveyance, total quantity of goods and, usually, the weights.

The checker's slips are passed to the office, and particulars are entered into the stock book. The date, total tonnage, and cubic feet capacity are entered into the rent account ledger, against the customer's name, and the amount of storage charge for the first month posted accordingly.

Cold store charges are usually based on monthly rates, any part of a month counting as a full month, and are inclusive of the day of entry and the day of delivery. One month is taken as being 28 days, and thirteen months to the year.

When an order is received in the office for delivery of any part of the stocks in store, a special delivery order is made out ; usually this is in triplicate, but often more than three copies are required. The number of the delivery order is then posted in the main stock book against the receipt posting of the particular item to be delivered. One copy of the delivery order goes out to the loading bank, and the foreman on the bank will issue the stock against this. When the delivery has been completed, and all the particulars and weights have been entered on the delivery form, the person taking the delivery signs as having received the goods correctly and in good condition. The signed copy of the delivery order is returned to the office and is filed, after first being checked with the main stock book posting to show that the correct

delivery has been made. The delivery posting in the main stock book, is then checked in the rent account ledger, and a posting made to close the storage charge.

This, in brief, completes the cycle of cold storage stock keeping. There are, of course, many variations. Let us now take it step by step, and see how the importance of correct checking is made apparent with each step.

NO. 3500

CHECKER'S RECEIVING NOTE

NORTH HAVEN COLD STORAGE CO. LTD.

PHONE 327

A/C M ______________________

____

EX ______________________ 194__

CART OR VAN NO. ____________ TIME STARTED ______

CARRIER ____________ TIME FINISHED ______

CHAMBER	MARK	QUANTITY	DESCRIPTION OF GOODS	REMARKS

REF. NO. ______

CHECKER'S SIGNATURE ______________

Fig. 6.—Checker's Receiving Note.

RECEIVING GOODS IN STORE

The checkers record all receipts into books having duplicate numbered sheets, the original being perforated and when completed torn from the book and sent down to the office. Usually, it is found better for checkers to have two books, "A" and "B," to be used on alternate days. Whilst the "A" book is in use on the loading bank, "B" book is being checked in the office.

The checker's slips show the following details :—

(i) Date the goods were received in store.
(ii) Ship, store, or wholesaler from which, or by whom the goods were despatched.
(iii) Rail, van, or lorry number.
(iv) Name of carrier.
(v) Time that unloading commenced.
(vi) Time that unloading finished.
(vii) Number of the chamber into which goods were loaded.
(viii) *Mark*.—All goods have a special distinguishing mark. Sometimes this is a name (often the name of a factory—at other times just a letter). This mark must be shown, and also a full description of the goods. If, for example, the goods are beef quarters, the descriptions whether they are fores or hinds, etc., boneless or bone-in, must be stated.
(ix) *Country of origin*.—Whether Brazilian, New Zealand, Uruguayan, etc.
(x) *Full description of goods*.—Whether in bags, boxes, or carcases, etc.; whether cuts, offals, and any other particulars of a descriptive nature.
(xi) *Quantity*.—As the goods are unloaded and piled on to the cold store trucks the number must be checked off on the checker's slip. The total must then be written at the bottom, preferably in words so that no wrong reading can be taken.

    Usually, the numbers on a checker's slip refer to the number of the loaded store trucks. The actual quantity of packages of goods received is shown in words. In most stores, it is customary to load the store trucks with a set number each time, *i.e.*, twenty carcases or twenty cases, so that only the actual number of loaded trucks then need be counted.
(xii) Any special remarks on the condition of the goods.

The checker then signs the slip and takes it to the office.

Landing Accounts or Receipt Notes

Checker's slips are checked by the office staff—to see that all particulars are entered correctly and that quantities are totalled. When all the checker's slips dealing with the one consignment are collected, a summary of the quantities is made out on a Landing Account, which also gives full particulars of the marks, etc., as follows :—

(i) Date the goods were received.
(ii) Ship or port of despatch.
(iii) Chamber number.
(iv) Marks and descriptions.
(v) Quantities.
(vi) Any special remarks on condition, etc.

Stock Books

The stock clerk posts the details from the Landing Accounts into the loose-leaf stock book, using a separate page for each mark, in Receipt columns, as follows :—

(i) Date received.
(ii) Reference number.
(iii) Chamber number.
(iv) Marks.
(v) Quantity.
(vi) Description.
(vii) Name of customer.

Bone-in beef is usually written B/in. Boneless meats are written B/less. F signifies forequarters. H is written for Hinds. R and P would mean Ribs and Ponies. Code numbers are used as follows :—

1 = Butter.
2 = Beef bone-in.
3 = Boneless beef.
4 = Offals.
5 = Lambs.
6 = Sheep.
7 = Porkers.
8 = Pork sides.
9 = Veal.

The reference code is not always necessary, but in stores receiving different consignments daily, a reference code is useful, especially for marking the stacks in the chambers.

An example of an entry would be as follows :—

Date.	**Ref.**	**Chamber.**	**Mark.**	**Quantity.**	**Descpt.**
5/6/	F.1/3/2	12	Braz.	1500	B/in F.

The reference number is explained by :—

F. = June. (Month of year represented by A to M).
F.1. = First week in June.
F.1/3/ = Third shipment in first week in June.
F.1/3/2 = Third shipment of bone-in beef in first week of June.

Returns

Landing accounts are made out in duplicate. The original is sent to the customer, the duplicate is for the office file. Very often, progressive landing accounts are required daily, in instances of large consignments, showing the total quantity received, including the day's receipts, the balance to be received, and the total consignment anticipated.

Particulars of any goods received in damaged condition should be shown separately on each landing account.

Usually, all consignments of goods received at a cold store have a corresponding consignment note, sent by post. These consignment notes give

details of the lorry or rail van numbers and the contents. The contents are checked against the checker's receiving slip, and a note is made on the consignment note, in red ink, to show whether the consignment is correct, short, or over. The consignment note is then signed by the receiving agent at the cold store, and returned to the senders.

LANDING ACCOUNT

NORTH HAVEN COLD STORAGE CO. LTD.

PHONE 327

RECEIVED FROM ____________________

NO. ______ NORTH HAVEN ________ 194

QUANTITY	DESCRIPTION OF GOODS	LOT NO.	MARKS	STEAMER	WEIGHT	S.B. FOLIO
	CONDITION AND CONTENTS UNEXAMINED					

ALL GOODS STORED SUBJECT TO CONDITIONS ON BACK HEREOF

Fig. 7.—Landing Account.

DELIVERIES

An order to the loading bank foreman for the delivery of any goods should not be made out until the authority for the delivery order from the customer has been checked.

The delivery order is checked with the stock book to ascertain particulars of marks and quantities, etc., are correct. The delivery order nun is then entered in the stock book, and the delivery order to the loading b is made out, giving all the necessary information, such as chamber num name, mark, quantity, etc.

The foreman on the loading bank having scanned the details on the deli order, gives the necessary instructions to his gang and hands the order to

DELIVERY ADVICE PHONE 3

NORTH HAVEN COLD STORAGE CO. LTD. ______1

MESSRS.______

WE HAVE THIS DAY DELIVERED ON YOUR ACCOUNT:- QUOTE THIS NO. ______

QUAN.	DESCRIPTION OF GOODS	MARKS	STEAMER	WEIGHT	PER

NORTH HAVEN COLD STORAGE CO. LTD.
PHONE 327

______194

MESSRS.______

DELIVERY ORDER NO. PER

MARK	QUAN.	DESCRIPTION	EX	WEIGHT-LBS.

Fig. 8.—Delivery Advice Specimens.

checker. As the goods are brought out of the chamber, and before they ar loaded on to the lorry, the checker checks and weighs and then records th necessary particulars on his slip. In addition to all the particulars recorde on receipt of the goods, deliveries usually have to be weighed, and the checke has quite a lot of writing to do. He must show the following :—

(i) Name and address of cold stores.
(ii) Number of delivery.
(iii) Date.
(iv) Reference number.

(v) Chamber number.
(vi) Marks.
(vii) Quantities.
(viii) Description of goods.
(ix) Gross weight.
(x) Tare weight.
(xi) Net weight.
(xii) Name and address to whom goods are to be delivered.
(xiii) Account details.
(xiv) Van number.
(xv) Time loading was started and finished.
(xvi) Checker's signature.
(xvii) Receiver's signature.

Some stores have the delivery orders printed in different colours, the original being white, the duplicate green, the triplicate pink, and the quadruplicate yellow.

The white copy is handed to the carter demanding delivery. He takes this to the store's foreman on the loading bank. The goods are then brought out of the store, weighed, checked, and loaded. The weight, the time loading was started and finished, are noted by the checker on the white copy. After signing it, the checker hands it to the carter accepting delivery, who takes it to the office.

The stock clerk checks the weight and quantities and other details. If these are correct, the four forms are placed together, with carbon sheets between, and the carter signs the white form. Thus the signature of the carter accepting delivery is on all four copies. The yellow copy is handed to the carter, who shows it to the gateman as he passes out of the store ; the gateman having instructions not to allow anyone to take goods out through the store gate unless a yellow delivery form is produced.

The white, green, and pink delivery copies are then passed to the clerk in control of the main stock book. The particulars of the delivery are posted in the delivery column opposite the receipts column posting, and the quantity balance brought down.

The green, white, and pink copies are then stamped as having been checked and posted. The green copy is sent to the office of the customer, the pink copy is sent to the depot where the delivery has been taken, and the white copy is filed.

Very often, the office of the customer and the depot are one and the same, in which case there is no need to send the pink copy. Generally, however, the head office and depot are two different places and two copies are necessary.

These copies of cold store delivery orders act as advices, and occasionally as consignment notes, in which case no others are required.

Where a delivery is of such a quantity that more than one vehicle must be used, the cold store delivery order is made out first of all for one item, the

quantity of which is left blank. The order is written—" Part order of ...." The checker fills in the amount loaded on the first vehicle and the order is returned to the office. The stock clerk then makes out the delivery order for the next vehicle for the balance of the same item.

CO-ORDINATION

The preceding paragraphs cover the system used in most cold stores. There are variations, of course, depending on the class of business and the commodity stored. The checker should know, and understand perfectly, how much is dependent on him. He should realise how a small error, unless discovered and remedied, will affect the whole of the office records. On the checker lies the responsibility for the co-ordination of the main stock books and the actual physical stock position.

A feature of good management and cold store efficiency is the absence of mistakes. If at the end of a parcel of any quantity, large or small, of any particular " stow " of goods held in store, the last delivery balances to the last quarter, or bag, or case, or unit, then perfect co-ordination between office and loading bank or " deck " is plainly evident.

Very often, the store foreman may ask the stock clerk how many quarters of beef or lamb carcases are in the store against the name of a particular customer. The stock clerk's answer may raise misgivings in the mind of the foreman. It is impossible to count exactly the number of bags there may be in a particular stack, but the foreman soon becomes accustomed to assessing quantities stowed in bays or in certain parts of the chambers. The question arises then, if the foreman has misgivings, should he inform the office that he fears a shortage in stock, or should he wait until the stack is small enough to count ?

There is only one answer. All differences should be settled immediately. All suspicions of differences should be declared immediately, and steps taken to investigate the possibility of a mistake having been made.

How can a shortage occur ? One of the most frequent causes is that of a rail van being wrongly labelled and shunted in a different direction. It may lie in a goods yard or a siding for days before being discovered. Many a rail wagon labelled empty has been found to be full. And when found, the contents have had to be condemned.

Mistakes can occur at the docks or port of discharge. An excess may be sent to one store, and a short consignment delivered to another. If neither store reports the error immediately, the delay will involve both money and work.

Mistakes are often made when intakes are being handled. A checker may have his attention momentarily distracted, and a loaded cold store truck may not be counted. Or he may count the same one twice. It is the easiest thing in the world to do. Such a mistake can be rectified before deliveries are made. But if not, the returns will be false, and all book postings will carry that mistake until the stock is cleared.

Methods of Co-ordination

Some store foremen keep their own stock books. But these, in the writer's opinion, are unnecessary. If the checker's daily intake slip shows the chamber number in which the intakes are stowed, and if all delivery advices bear the number of the chamber from which deliveries are made, accurate office records of stock in each and every chamber can be maintained.

A weekly stock sheet made up from office books giving the quantities and descriptions in each chamber is all that is necessary. The stores foreman should check on this stock sheet every week, and any item that appears to be wrong should be investigated immediately.

A chamber stow diagram is very useful, but if the daily movement is heavy, and turnover of stocks frequent, it will be found difficult to keep this up to date.

[*Courtesy*: *T. A. Raymond*

Fig. 9.—The Checker at Work.

Boards on the outside of stacks, indicating country of origin, description of goods, month of intake and name of ship, are really necessary. A check of these with the weekly stock list will be found to be all that is required to keep records up to date.

INSTRUCTIONS TO CHECKERS

Instructions to checkers cannot be too detailed. The following example sums up the main points, and the conscientious checker should keep these in mind.

Receipts and Deliveries

1. A claim against the store recently for the delivery of a box of bacon, short weight, has made it necessary again to point out the importance of a checker's duties, and the desirability for preventing further claims.

2. In practically every case, the claims against the store have been due to errors on delivery advices or on receipt notes.

3. It cannot be too strongly stressed that checker's receipt notes must have full and complete information. Accuracy is essential.

4. When making deliveries, if at any time checkers suspect that details of the deliveries being made are different from the details originally made on the checker's receipt notes, the delivery must be delayed until comparison with the receipt note and landing account has been made. This is especially important with bacon. The following notes may be of assistance :—

5. *Bacon.*

(i) All bacon received damaged must be test-weighed. In other words, these boxes or bales must be opened, the contents examined, and put on the scale.

(ii) If the test weighing cannot be done immediately, the damaged cases and bales should be put on one side. The receipt note should then show : " Damaged—Test weight to follow."

(iii) When making deliveries of damaged cases or bales of bacon, the checker must ascertain whether test weighing has been made and reported. The delivery scale weight should agree with the scale test weighing on receipt note.

6. *Cased Meats.*

(i) When making deliveries of cased meats such as offals and pork cuts, the marked net, gross, and tare weights must be shown on advices. In addition, the gross scale weight must be shown.

(ii) Where cases are broken, or the marked weights are not decipherable, deliveries should be made of net contents only, and net scale weight should be shown on delivery advices, clearly marked " Net Weight."

(iii) Particularly with offals, the fullest information should be given on delivery advices. Net and gross weights are important. Tare weights are particularly important. The description, whether parcel is cased, bagged, or cartoned should be noted. In the case of kidneys in cartons, the number of dozens per carton should be quoted.

7. *Meats.*

Delivery advices must show gross and net weights, and allowances for tare.

Allowance for tare varies from time to time according to the class of hessian wrapper used. Generally, tare of 1 lb. is allowed for South American, and $1\frac{1}{2}$ lb. for Dominion meats.

Full net weight, in agreement with the delivery order, must be delivered irrespective of the number of bags specified.

8. *Butter.*

The receipt of any damaged boxes of butter involves test weighing, and a full report. Delivery of any damaged boxes of butter should not be made until it has been ascertained by the checker that a full report of receipt of damaged box has been made by the office. The exact weight, and the amount short must be quoted.

9. *Cold Store Trucks.*

To avoid mistakes, and to check queries *re* weighings of deliveries, it is imperative that at all times the *same* number of bags or boxes or carcases must be loaded on to trucks.

For example :—

Butter	20 boxes.
Lambs	20 carcases.
Sheep	15 carcases.
Beef	5 quarters.

On no account should any delivery advices show scale weighings for different numbers of bags or cases.

10. *Laying Out.*

It is important that when meats are received soft, or in an otherwise unsatisfactory condition, the actual number received, laid out, and put on one side for inspection is quoted on receipt notes, and a full report given as to condition.

In some stores, checkers combine office duties with those of checking. In other stores, checkers combine the duties of ordinary warehouseman with checking. It is a moot point which arrangement is the better. The author favours the system of the stock clerk's assistant and the checker being one and the same person. Much, however, depends on the type of store and the class of business.

It will be seen from the foregoing that a great deal depends upon the checker realising that his duties and work must be taken seriously. Recruitment of checkers should therefore be made with care. Men must be chosen of the right type. An indifferent, careless checker is definitely a liability in any store. It cannot be too strongly emphasised that to be a good checker, a man must realise the amount of unnecessary work a checking mistake can cause in an office.

CHAPTER 4

TRUCKS

TYPES OF TRUCKS

There are trucks for every purpose. In general or dry warehousing, there are elevating, tipping, racking, shelving, caging, craning, tanking, and jacking trucks. There are also turntable trucks, and trucks specially designed for different operations. For cold store work three types only are generally seen. The four-wheeled truck, the two-wheeled truck, and the transporter truck. Of the four-wheeled truck designs, only three types are favoured. Each of these types differs only in the upper bodywork. A baseplate, wheels and axle of the sliding wheel type have been proved to be the most satisfactory. The main features are :—

A sliding wheel at each end.
Only three wheels touch the ground at the same time.
The load is used as a lever in starting and also in turning.
The centre wheels run on ball bearings.

The baseplate can be either of hardwood or chequer plate ; the axles should be of steel, and the wheels are generally of cast iron.

Variations in the design of the upper body work are many, but the most serviceable are those illustrated in the following pages. The carcase truck with enclosed sides, the bacon truck with no upper bodywork at all, and the open side truck, are the three types that best suit cold store work.

All trucks should be numbered and have the tare weight painted on the side. This weight should be tested periodically as it will be found to differ occasionally. Wear and tear, and a gradually increasing thickness of grease and fat, which even the most rigorous cleaning will not remove, will necessitate adjustments. These adjustments can be made by adding or removing the weights usually fitted on the centre axle.

Most cold stores keep a truck book, ruled up as follows :—

Truck No.	Tare Wt.	Date adjusted.	Remarks.

The extent of scale weight differences is easily apparent when the following example is considered.

The tare weight of the truck as shown by the marking on the side of the truck is 330 lb. and a delivery of 3,000 lb. of meat is to be made. If twenty lamb carcases, each averaging 30 lb., are loaded into the truck and the truck put on the scale, the reading should be 930 lb., since the net weight of the lambs is 600 lb. But suppose that the weight of the truck has not been tested for some time, and that the actual tare weight is not 330 lb. but is 335 lb. Then

the apparent net weight of the lambs will be 605 lb. Thus there is a scale difference of 5 lb. for every truck weighing. In weighing out 3,000 lb. of lamb the truck would need to be loaded and scaled five times, because 3,000 lb. of lamb with lamb carcases averaging 30 lb. each would require one hundred carcases, and at twenty carcases per truck load, five loadings would be necessary. If there is a scale difference of five lb. each time, then the total difference would be twenty-five lb.—practically one whole lamb carcase.

HARD SERVICE OF TRUCKS

There is no other item of equipment in cold stores that is in such constant demand, so roughly treated, and yet receives such little attention, as the truck ; and yet it is vitally important and necessary to the smooth working of the store.

Sixty tons movement per day means approximately nine rail vans, or twenty average sized motor vehicles. It also means that an equipment consisting of twenty four-wheeled trucks will be loaded at least six times, and probably more—dependent on the commodity. In other words, each of those four-wheeled trucks will be loaded and unloaded from six to ten times each working day ; will make up to twenty journeys along the loading bank, ten loaded and ten unloaded ; will enter the lift cage, will leave the lift cage, bumping its wheels over the step ; will enter and leave the chamber, bumping its wheels again over the chamber door sill or ramp. And it will be loaded each of the ten times, with, say, twenty carcases or cases, each one of which is hard and frozen and lands on the truck baseplate with a thump. Two hundred thumps a day !

It will thus be appreciated that each truck must be built to withstand rough service. It must at the same time be light and run freely. It must run easily both ways, and must turn or swivel with the slightest effort. The sliding wheels on the front and back axles are slightly smaller in diameter than those on the centre axle. But this difference must not be too much, otherwise the truck will rock, and will require holding or scotching when being loaded.

NUMBER OF TRUCKS REQUIRED

The number of trucks required is governed by the daily handling capacity of the store. Several factors determine the handling capacity, and of these the storage capacity is the least important.

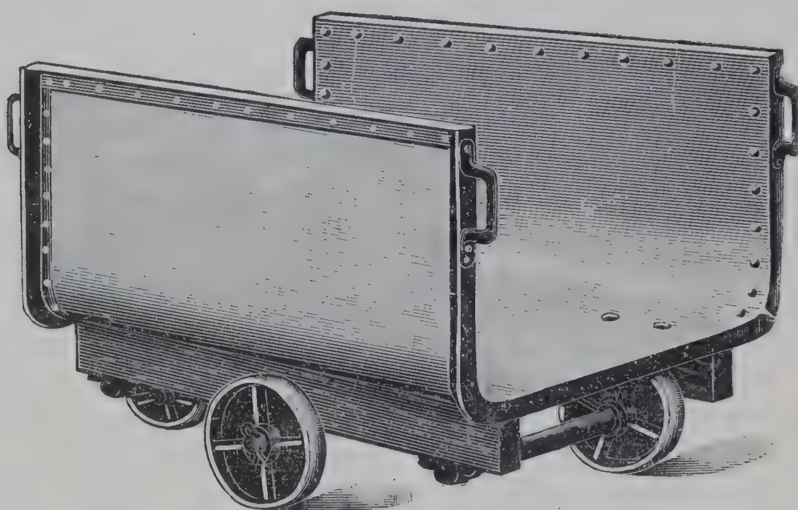
A popular impression appears to be that the handling capacity is one-sixteenth of the storage capacity of the store. An analysis of the stores in this country reveals that while one-sixteenth of the storage capacity is the maximum handling capacity, less than fifty per cent. of this represents the average daily handling.

It can be said, therefore, quite safely, that the handling capacity is roughly one-thirtieth of the storage capacity of any store. For example, a 2,000-ton capacity store should have equipment to warrant a daily movement of sixty-six tons.

That this amount will occasionally be exceeded is, of course, only to be expected. We are considering a daily average taken on figures from a full year's working. Thirty tons daily movement per thousand tons storage is a reasonable yearly average.

Based on this, therefore, a store averaging a daily movement of one hundred tons means approximately fourteen railway waggons, or one and a half times that number of motor vehicles. It also means about five hundred four-wheeled cold store truckloads.

Obviously, no cold store could have space for such a stock of trucks. Therefore, it follows that each truck must be loaded at least ten times. Making the cold store truck larger, so that it will contain more and so reduce the number of loadings and journeys, defeats its own object. The trucks must be of the



[*Courtesy*: *H. C. Slingsby*

Fig. 10.—Sliding-Wheel Truck.

correct dimensions ; dimensions are all important. Trucks that are too small slow down movement ; trucks that are too large make handling difficult and increase the physical effort required to push them. The dimensions of the lift cage also govern the size of trucks. For some unexplained reason, the average cold store possesses lift cages that are either too large to contain two trucks or just not big enough for two. Few cold stores possess lift cages large enough to contain comfortably the number of loaded cold store trucks which bring the lift load to the authorised safe carrying weight.

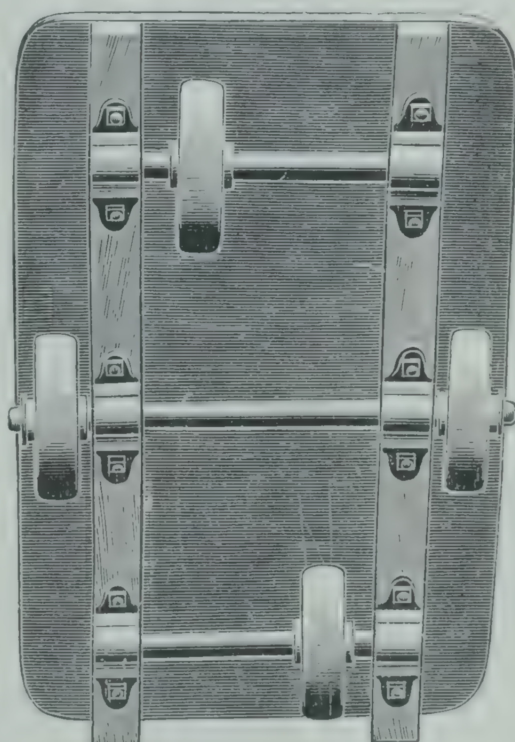
THE FOUR-WHEELED TRUCK

There are several types of trucks of the sliding wheel type, and new types appear every year. But each design omits one or other of the factors which govern the size, type, and design necessary for cold store work. The idea behind the sliding wheel principle is that the truck can revolve or swivel easily.

t can run easily both ways. The reduced diameter of the sliding wheels together with the weight of the load makes rocking a simple matter. The rocking, ogether with the weight of the load, helps the truck to start no matter whether he truck is pushed or pulled. The same principle is involved when the truck s required to be turned—the load is effective in helping the wheel to slide along the axle.

An improvement is the fitting of springs each side of the sliding wheels. This gives a cushioning effect to the pivoting and prevents the truck from turning too freely.

The relationship between the diameter of the sliding wheels and the diameter of the two central wheels requires careful consideration. If the loading bank surface is new and level, the trucks should have very little "rock." In other words, the reduction in the diameter of the sliding wheels should be very slight. If the loading bank surface is not smooth, and there are considerable bumps and hollows, then the diameter reduction should be greater.



[*Courtesy*: *H. C. Slingsby*

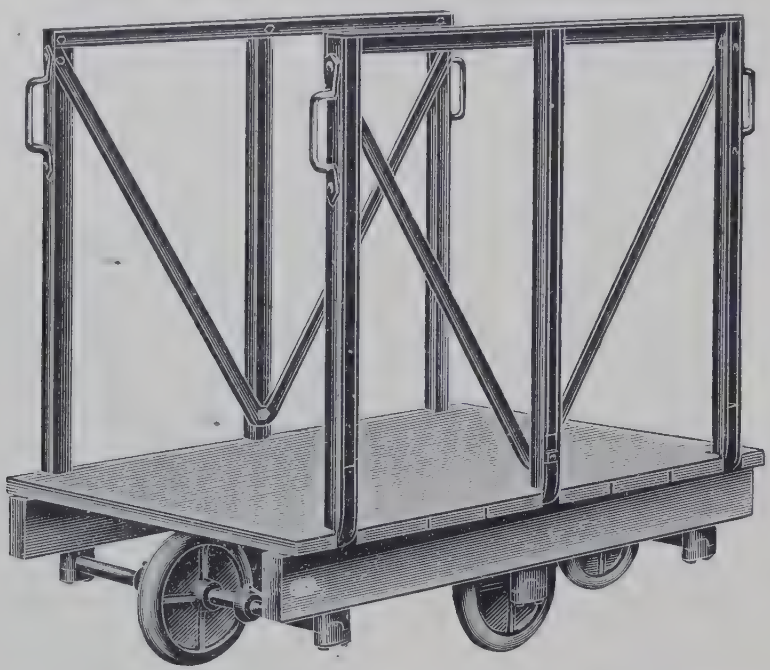
Fig. 11.—Baseplate of Truck.

The construction of sliding-wheel trucks is usually of 4 in. by 4 in. hardwood beams with a 1 in. hardwood platform. The uprights forming the sides are made of wrought iron, pipe, angle, or T-iron. Sometimes the wood platform is covered with sheet iron. A better type of truck is the all-iron truck, where the platform is made from one-quarter inch chequer plate mounted on 4 in. channel iron.

The axles are, of course, of steel. The wheels and axle boxes are cast iron and in the better type of truck, ball races are fitted. This ensures easy running, and makes a wonderful difference to the amount of physical effort required to push a truck. The wheels are sometimes rubber tyred. Rubber tyres are, however, not always an advantage. They are liable to stick if the floor is greasy, and most cold store floors are covered with fat.

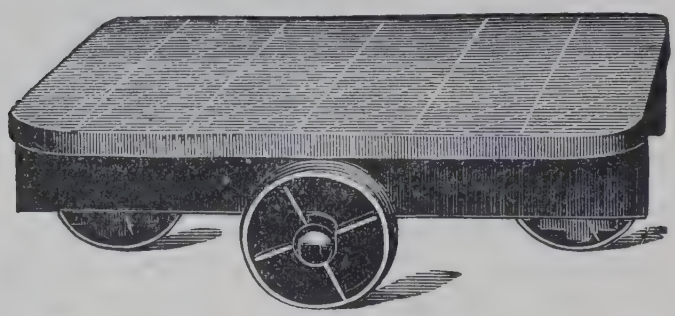
Cold store trucks should have a capacity for twenty lamb carcases, for twenty cases of butter, or for five quarters of beef. Thus, with any one of these three commodities, a loaded truck has a weight of between five and six hundred lb. This load is quite sufficient for the average truck man to push along a loading bank.

Trucks are made in various sizes. The size recommended has an insid length of platform of 55 in. and an inside width of 32 in. The height of th sides should be not more than 36 in. The diameter of the centre axle shoul be $1\frac{1}{4}$ in., with wheels of 10 in. diameter.



[*Courtesy*: *H. C. Slingsby*

Fig. 12.—Another Type of Four-Wheeled Truck.



[*Courtesy*: *H. C. Slingsby*

Fig. 13.—Bacon Bale Truck.

The weight of the truck itself should be not more than three hundredweight. The carrying weight of a truck of these dimensions will never exceed a thousand pounds. There is an extensive weight range in cold store commodities. Bacon, for example, arrives in two hundredweight bales, and six hundredweight cases. Quarters of beef average one hundred and fifty lb. Crates of bananas, cases of cheese, and cases of fruit vary in weight, shape, and size.

In lubricating trucks, use anti-freezing oil or grease. Trucks are subject to great changes of temperature and humid conditions. They are often left in chambers overnight.

TWO-WHEELED TRUCKS

The number of this type of truck required depends mainly on the ommodities handled by the cold store. As a rule, it is safe to estimate half he number of four-wheeled trucks. For a 100,000 cubic feet or 800 to 1,000 on cold store, at least ten two-wheeled trucks, and twenty four-wheeled trucks re required.

On this basis it would appear that sixteen four-wheeled trucks, and eight wo-wheeled trucks are necessary per 50 tons daily handling capacity, or per ,500 ton storage capacity. This appears to be at variance with the figures

[*Courtesy*: *H. C. Slingsby*

Fig. 14.—Two-Wheeled Trucks for Cold Stores.

given in the preceding paragraph. Ten and twenty trucks of each kind, respectively, for a 1,000 ton store is the average equipment. Sixteen and eight trucks of each kind, respectively, for a 50 ton average daily movement should be the absolute minimum.

On the other hand, the class of commodity handled at the cold store governs to a large extent the number of two-wheeled trucks required. The two-wheeled truck is most suitable for bacon, and stores handling a lot of bacon would probably have more than 50 per cent. of their truck equipment confined to the two-wheeled type.

The two-wheeled truck most suitable for cold storage is the type known as the sack truck. Usually this is made with hardwood shafts and crossbars—the

crossbars numbering either two or three—and there is a final facing of h
iron, ending in a foot lip of 4 in. width.

Many two-wheeled trucks in use at cold stores have far too wide a li
6 in. being the average.

Actually, a 3 in. width of foot iron is ample. The narrower the foot iro
the easier it is to withdraw the truck from under the case when pitching th
case into position.

The flat bar iron facing should be extended to at least three-quarters of th
length of the shafts. The crossbars should be flat, not curved, and the fo
iron should be square, and not round.

[*Courtesy: H. C. Slingsby*

Fig. 15.—Bacon Truck.

The length of the shaft should be no
more than 45 in. The width between th
shafts should be not less than 18 in. at th
top, near the handles, and 12 in. at the foo
The diameter of the wheels, which are cas
mounted on an axle made from 1 in. squar
bar iron, should be at least 8 in.

If the wheels are placed inside the shafts
instead of outside, this is often found to
be an advantage, and the wheels have a much
longer life.

The wood should be well varnished
and must be thoroughly well seasoned
otherwise it will not stand up to the work
and will develop cracks and splits because
of the temperature changes to which it will
be subjected.

There is a type of truck for bacon work
which is finding increasing favour. Instead
of a foot iron there are four spikes. The
case or bale rests on these spikes and is easily
jerked off when "landing."

With increase of capacity and consequent
increase in daily tonnage movement, a
proportional increase in truck equipment becomes an obvious necessity.

Insufficient truck equipment slows down movement, and seriously affects
the speed of intake and delivery. Loss of reputation is the consequence, and
business suffers.

On the other hand, it is very often a problem to know what to do with
trucks that are not being used. They are an encumbrance, especially if loading
bank accommodation is limited. Nevertheless, since trucks are such an essentia
part of cold store equipment, space must be found for them.

Regular truck-maintenance work should not be neglected. In most cold
stores, this work is undertaken by the engine-room staff, and usually th

ngine-room attendant and his mate have a job of some kind to do on trucks hile they are on watch. The proper place for a defective truck is outside the ngine-room door, to await the attention of the engine-room staff. Each epair should be logged in the Truck Book, and each truck should have a listory Sheet. Certain methods of handling can shorten the lives of trucks as vell as others can prolong them. A series of similar defects, occurring over period, should be enquired into, and the cause ascertained. Frequent broken xles can usually be traced to too high pitching, or to a particularly bad hollow n the loading bank or chamber floor.

TRUCK FOR CHILL ROOMS

Although chilled or freshly killed neats are not usually handled in tores, except those near to an battoir, there are occasions when hilled space is asked for. In chill ooms, specially built for freshly killed meats, hanging rails are fitted complete with switches, hooks, and chains. Where these rails are not itted some method of hanging must be adopted. A simple method is to make use of an ordinary truck as shown in the diagram. In this truck the sides have been dismantled, leaving only the base platform, o which rails made of one-inch piping are fitted. There are four or six uprights, and rails above. Each truck can accommodate thirty amb or sheep sides or fifteen carcases.

[*Courtesy: H. C. Slingsby*

Fig. 16.—Chill Room Truck.

TRANSPORTER TRUCKS

The smaller store handling small packages, and with stowing in chambers nvolving numerous separations, is making increasing use of the transporter truck with boards.

Operation of these trucks is simple. One man can lift, transport, and stack in position in the chamber, a board loaded with twelve hundredweight. The platform or board or container, usually 40 in. long by 36 in. wide, is placed on the loading bank. The cases or packages from the lorry or van are loaded on to it and when the required load is completed the transporter truck is wheeled under the board. The connecting bar on the handle is lifted by a touch, the handle is pulled over, and the load is ready for transporting to the chamber.

The truck is taken close to the stack in the chamber ; a touch on the connectin bar, and the truck can be wheeled away leaving the load ready stacked i position.

An improvement on the transporter truck is the special lip truck, whic is suitable for the large cold store. It will be seen that the principal equipmen in cold stores consists of the truck, dunnage, and the stacking machine. I the special lip truck the functions of all three are combined. This three-in-on combination, together with its power-driven unit, enables both man powe and handling cost per ton to be considerably reduced, speed per hour to b increased, and all dunnage and stacking problems to be solved. Easy stowing and easy deliveries are facilitated. Checking is made easier, and physica counts inside chambers become a simple matter.

Instead of eight to ten men servicing one vehicle irrespective of whether goods are inward or outward, three men would be found quite sufficient. Each stage of the handling system—loading, transporting, unloading and stacking—with the special lip truck handles a number of units at once. The more pieces, or the greater the weight handled at each phase, the lower the cost per ton. The time taken will be correspondingly reduced so that the cost per ton is decreased, and the speed per hour increased.

The transporter truck with board as used at the smaller store can handle small packages only, and each load transported to the chamber occupies so much floor space whilst wasting all the head room above. The double-faced board as used with the special lip truck is specially suitable for stacking, and snuggles easily into the tier while affording a perfect base for the next tier above. The stacker fitted to the truck lifts the load easily on to the stack, and can attain the height of the ordinary chamber stack comfortably. No head room need be lost in the usual ten-foot high chamber.

These special lip trucks are power driven and can be obtained in various sizes. The type suitable for cold storage work has an overall height of ten feet with full extensions of uprights up to seven feet so that truck and stacker combined can pass freely through the chamber doorway. The toe-plate or lips of the truck fit the spaces of the double-faced transporter board, and lifting is accomplished by foot or power. Lifting range during transporting need be only a few inches. The full lift is, of course, made only inside the chamber.

Special lip trucks need not necessarily go inside the lift cages. Boards with their loads can be transported by the trucks and deposited in the lift cage. Lip trucks kept on the chamber floor levels will take the boards with the loads out of the lift to the chamber. If loads due to the awkward nature of the packages show signs of capsizing from the boards during transportation, a couple of thin battens to act as rails can easily be fitted to the sides of the boards. These can with advantage go into the stack.

CHAPTER 5

DUNNAGE

PURPOSE OF DUNNAGE

DUNNAGE, the timber used for stacking and stowing, is an expensive item of equipment, but a very necessary one. The majority of cold stores, however, do not use sufficient.

The purpose of dunnage is to provide airways, to ensure air circulation, to obtain the maximum ventilation, and to prevent dead air pockets.

Any stack of meats, unless provided with air passages, is liable to bind together. The centre of the stack will heat up, the centre bags will defrost, and once defrosting commences there is every possibility that the whole of the stack will be affected.

Air cannot circulate if goods stored are placed direct on cold chamber floors. For this reason goods are placed on 3 in. by 3 in. dunnage laid on the floor with due regard for direction of air flow. The dunnage should be spaced at not more than two-feet centres, and very often at less, dependent on the class and variety of goods. For example, with cases of butter, the dunnage would need to be spaced at not less than twelve inches—or two lengths of dunnage to each case.

If stowing boneless beef in bags of seventy to eighty pounds, dunnage would need to be placed between each, or at least every second, layer of bags. This is necessary, otherwise it is possible that all the bags, especially if they are a little soft, will freeze together and make one solid pack. To separate "sticky" bags requires a lot of effort, and when required for delivery, the bags may be torn, and show signs of the work necessary in separating the stow.

It follows that the amount of dunnage required in a store can be considerable. Based on modern practice, it can be calculated that for every 1,000 cubic feet capacity, 150 running or lineal feet of dunnage will be necessary. A 50,000 cubic feet store will require 7,000 feet of dunnage, at the least. It is always advisable to have too much rather than too little.

PERMANENT DUNNAGE

A good percentage of floor dunnage can be fitted as a permanent fixture. In stores with concrete floors it can be made from reinforced concrete; in chambers with wooden floors it can be screwed to the floor. Permanent floor dunnage has the advantage that it is laid once and for all time in the right direction. In too many stores dunnage is laid in the wrong direction, baffling the air flow, and thus preventing free air circulation.

Permanent floor dunnage has to be laid so that it does not interfere with trucking space. For example, every fourth line of dunnage can be permanent. When stacking, three lines of dunnage would then have to be laid in between the permanent lines. When breaking down stacks, these three lines would be picked up and stowed away so that floor space could be cleared for trucks and for cleaning and sweeping purposes.

The problem of what to do with dunnage when it is not being used is always serious and sometimes baffling. Some stores use overhead racks, others just pile the dunnage anyhow at one end of the chamber. If dunnage is placed on walls in between permanent wall dunnage lines, it can be taken down as stacking proceeds. Placing it on walls is the best method.

QUANTITY OF DUNNAGE REQUIRED

There are three sizes of dunnage necessary in all cold stores: the 3 in. by 3 in., for floor dunnage; 2 in. by 2 in. for 'tween dunnage, used between bags, sacks, or quarters of beef; and 1 in. by 1 in., used for 'tween dunnage between cases, tins, or cartons, etc.

Dunnage is a part of cold store equipment that needs renewal occasionally. It gets broken very easily. Also, a good principle is to discard bloodstained dunnage, since bloodstains are liable to form breeding grounds for mould spore.

Dunnage is useful for erecting temporary divisions or cages in chambers when making separations. The majority of cold stores cannot know with certainty that each consignment received for storage will be exactly the same class of commodity, needing the same amount of dunnage. Too much, rather than too little dunnage must therefore be the policy of the management, and always sufficient, no matter what commodity is expected.

A rule of thumb for estimating dunnage requirements is as follows:—

For each 100 tons storage capacity allow 1,300 running feet of dunnage.

Or,

For each 1,000 square feet floor area allow 1,600 running feet of dunnage.

Thus, taking for example a store of 100,000 cubic feet, and estimating a net storage capacity of 1,000 tons of meats, butter, and cheese, the minimum dunnage required would be approximately 13,000 running feet of 3 in. by 3 in. dunnage.

Allowing 600 tons of meats, 300 tons of butter, and 100 tons of cased goods or cartons, the 'tween dunnage of 2 in. by 2 in. lengths would total 10,000 running feet.

In addition, possibly 3,000 running feet of 1 in. dunnage would be required.

Of late, the tendency has been for a greater quantity of boneless meats than of bone-in meats to be found in cold stores. Many stores are not using 'tween dunnage for boneless meats. The necessity for 'tween dunnage is, however, real, especially if long storage is probable.

Taking a chamber 100 feet in length and 60 feet in width with a door in the centre of the short wall, stacking will be commenced in the centre of the chamber, at each side, working towards each end. A central gangway, wide enough to permit trucking, will be left clear, and will be the last space to fill. The floor dunnage will usually be placed from the walls to the gangways, if pipes or air ducts have been erected with due regard for the length of the room, and the situation of the door. If meats are to be stacked, the dunnage will be laid at approximately 18 in. centres. As dunnage is usually supplied in 15-foot lengths, it may be necessary to have shorter lengths placed end to end with the longer lengths, allowing the minimum central gangway. Allowing for minimum air spaces of, say, 6 inches between the stacks, it will be seen that each side of the chamber will take up at least 100 lengths, so that the minimum floor dunnage alone will amount to 1,600 feet. If stowing bales of bacon, double this quantity will be required.

The above is given purely as an example to illustrate the amount of dunnage which can be used in any one chamber.

Presuming that this chamber is to be stacked with boneless beef, at least 6 quarters high, and allowing minimum 'tween dunnage, that is, dunnage placed between every second layer, it will be appreciated that the 'tween dunnage required will be twice the quantity of floor dunnage.

Actual Example

The dunnage requirements of a 250,000 cubic feet store may be calculated as follows :—

The store has twelve chambers, each of 20,000 cubic feet, and a small chamber or cooled vestibule or air lock of 10,000 cubic feet. The small chamber should be disregarded, as this is used mainly for overflows or for inspections, and is never completely occupied.

The chambers are approximately 60 feet by 30 feet by slightly over ten feet high. The main commodities stored are the usual meats, bacon, and cased butter. Generally there is 70 per cent. meats, 20 per cent. bacon, and 10 per cent. butter. The minimum total of dunnage required would exceed 26,000 running feet.

Floor Dunnage

Chamber No.	1.—Meats	...	60—15 ft.	lengths,	3 in. by 3 in.	= 900 ft.
,, ,,	2.—Meats	...	60—15 ft.	,,	,,	= 900 ft.
,, ,,	3.—Butter	...	100—15 ft.	,,	,,	= 1,500 ft.
,, ,,	4.—Bacon	...	100—15 ft.	,,	,,	= 1,500 ft.
,, ,,	5.—Bacon	...	100—15 ft.	,,	,,	= 1,500 ft.
,, ,,	6.—Meats	...	90—15 ft.	,,	,,	= 1,350 ft.
	—Butter	...				
,, ,,	7.—Meats	...	60 15 ft.	,,	,,	= 900 ft.
,, ,,	8.—Meats	...	60—15 ft.	,,	,,	= 900 ft.
,, ,,	9.—Meats	...	60—15 ft.	,,	,,	= 900 ft.
,, ,,	10.—Meats	...	60—15 ft.	,,	,,	= 900 ft.
,, ,,	11.—Meats	...	60—15 ft.	,,	,,	= 900 ft.
,, ,,	12.—Meats	...	60—15 ft.	,,	,,	= 900 ft.
			870—15 ft.	lengths,	3 in. by 3 in.	= 13,050 ft.

Thus the minimum floor dunnage would be 13,050 running feet of 3 in by 3 in. This would accommodate approximately 1,750 tons of meats, 500 ton of bacon, and 250 tons of butter.

To this must be added sufficient running feet of the same sized dunnage a 'tween dunnage for bacon—2 in. by 2 in. is a little too weak for bacon bales The question of how high bale bacon can be stowed depends upon the typ of labour, but to make the most use of space, the bales should be at leas seven high, even if a stacking machine has to be used. Two layers of 3 in. by 3 in. dunnage will therefore be required as 'tween dunnage, and this will eat up another 3,000 feet.

'Tween dunnage for meats, allowing for at least 50 per cent. of the mea tonnage to be boneless, will take at least 8,000 running feet of 2 in. by 2 in 'Tween dunnage for cased butter is not really necessary, but for cartons or other tight stowing commodities—or packs, a little 1 in. 'tween dunnage is always useful.

The minimum dunnage required, therefore, would be as follows :—

3 in. by 3 in. =	16,050 running feet.
2 in. by 2 in. =	8,000 ,, ,,
1 in. =	2,000 ,, ,,

STOWING WITHOUT DUNNAGE

It happens fairly frequently in cold store operation that intakes are being received when the discovery is made that no more dunnage is available. New dunnage can be purchased, of course, but it may be two or three days before it can be delivered. Intakes cannot be held up while awaiting dunnage. But it is imperative that meats be stowed so that airways are provided. Stacking must then take the form shown in the diagram on page 87. As will be seen, openings are left right through the stack. This means that in each layer the, bags are stowed slightly apart throughout the length or breadth of the stack in whichever direction is the air flow. It means considerable loss of space but it is the only remedy, and is the only method of safe stowing withou 'tween dunnage. Floor dunnage, however, must always be used ; there is no method of stacking without it. If none is available, then bricks, pipes, anything at all must be improvised—on no account must meats be stowed direct on to the chamber floor.

TIMBER USED FOR DUNNAGE

There are certain kinds of wood which are not very suitable for use as dunnage. Hemlock, for example, has an odour which can be detrimental in cold storage work. Pine, also, has certain disadvantages, not the least of which is the amount of rosin that can exude from it and stick to meats. Spruce is good and most suitable from other points of view. In buying dunnage for cold storage work, however, the main consideration is price. If the price is suitable,

the disadvantages of certain timbers will not rank very high in importance with the average manager.

The amount of dunnage required in a cold store, and the cost per running foot, can be so high that naturally, the cheapest timber possible will be bought. Safe rules therefore with all new dunnage are first, to see that it is thoroughly dry and well seasoned—do not buy any dunnage that has been oven or kiln dried ; dunnage of this kind will afterwards swell and be of little use—second, to ensure freedom from odours, or possible mould spore, give each layer of dunnage two coats of whitewash before placing in chambers.

Finally, once dunnage has been put into a chamber, see that it stays there until discarded. If dunnage is removed from a chamber and allowed to remain in an air lock or on the loading bank exposed to the atmosphere, it will commence to sweat. If it is then put back into the chamber the sweat or condensation will form an admirable breeding ground for mould spore.

CHAPTER 6

CHAMBER WORK

APPEARANCE OF CHAMBER

ONE glance inside a chamber is usually sufficiently revealing to the experienced cold store operator. The appearance of the chamber indicates the efficiency and experience of the staff and, in particular, the knowledge of the foreman. It is inside the chamber that these qualities are most needed, and it is here that cold store warehousing is displayed to best advantage.

[*Courtesy*: *"Modern Refrigeration"*

Fig. 17.—General View of Storage.

Different commodities call for different methods of handling and stacking. With certain meat packs it is difficult to stack them neatly. With other commodities the disregard of certain elementary rules will make for future trouble. Apart from the bad appearance of a chamber due to inefficient stowing, the two " crimes " of which any cold store foreman can be guilty, are mislaying parcels and allowing the growth of mould. Both of these can be entirely due to indifferent stowage methods—although mould is often traceable to several other causes apart from bad stacking.

It is surprising how many stores appear to stow on the principle of first in, last out. In other words, given an empty chamber, stowing will commence at the far end of the chamber, as far away from the door as possible. This is definitely working on the principle of first in, last out. It is surely obvious that stowing should start near the chamber door, so that the first stow in shall be the first stow out.

The most important rule of stowing, therefore, is to stow from door to wall, not from wall to door.

PLACING OF DUNNAGE

Dunnage must be placed the right way. This is especially important in air-cooled chambers. In other words, dunnage should be placed at right angles to air ducts. Air flow is from delivery duct across to suction duct, and dunnage should be placed in the same direction. Where, in small pockets, or because of protruding dunnage from other stows, it is impossible to lay dunnage the right way, the correct air flow can be ensured by laying other lengths across the first lengths of dunnage. This is known as cross dunnage.

In chambers cooled by pipes and where the air circulation is natural, all the dunnage should be placed in one direction. If there are wall pipes, the dunnage should be laid from wall pipes to wall pipes. Where there are no wall pipes but only ceiling coils, then dunnage should be laid from the end wall to the wall in which the door is located. A safe rule, however, with pipe chambers, is to lay dunnage along the length of the room, rather than across the width. But all the dunnage in any chamber should be laid in the same direction.

Where chamber walls are not fitted with permanent dunnage, then 2 in. by 2 in. dunnage should be placed between the stacks and walls. Actually, if stacks can be built without support, then correct stowage would be to leave a clear space between the stacks and the walls of at least 18 inches. This would ensure perfect air circulation, and would allow for inspection at the rear of the chamber.

There are two reasons why this is seldom done. One—although cases can be stowed without support, stacks of meat quarters and/or carcases tend to lie over, no matter how carefully the stack may be built. Two—a space of at least 18 inches all round the chamber walls adds up to a considerable amount and is a loss of insulated space. Every cubic foot of insulated space is a potential source of revenue, and no cold store could afford to waste space to this extent.

A loss of 2 inches by the use of wall dunnage is not so serious, and is necessary.

LOSS OF SPACE

There should be a valid reason for any and every loss of insulated space. A chamber of 20,000 cubic feet should hold at least 200 tons of commodities. At say, 30 shillings per ton month, the revenue from this chamber totals £300. If the chamber is, according to the stores foreman, showing one hundred per cent. occupancy, or in other words, is full, then the manager should feel assured that at least £300 monthly is being earned.

HEIGHT TO STOW

Goods should not be stowed above air ducts, otherwise the air circulation will be restricted. In pipe-cooled chambers stows should not touch pipes, but should be at least 6 inches clear. The gross capacity of a chamber 50 feet long by 30 feet wide by 10 feet high would be 15,000 cubic feet. Allowing 10 per cent. for gangways, dunnage, air ducts or pipes, the resultant net storage capacity would be 13,500 cubic feet. At 100 cubic feet per ton, this chamber, with 100 per cent. occupancy, should hold 135 tons and, at 30 shillings per ton storage rate, should yield a monthly revenue of £202 10s. When the chamber is full, the tonnage stowed therein will be shown in the stock books. If there is not a total of 135 tons, an investigation should be held into the loss of space. In all such investigations, the conclusion is invariably formed that the loss of space is due to stowing not high enough. The words—" Too much headroom "—could be written on most cold store Profit and Loss Accounts. A black or red line painted right round the chamber walls serves as a timely reminder to chamber men when stowing. The words—" Do not stow Above or Below this line "—painted above the line may look ambiguous ; they appear to imply that no stowing should be done at all. The chamber men in the store where these words were painted, however, know what is meant ; they have to stow to that line.

MARKING OF STOWS

The best method of marking stows is to have small, individual blackboards, about 6 in. square, hung on a column near each stack. Using white chalk, the description, month, and if necessary, owner of the commodity stored, can be written on each board—a clear indication even to the newest warehouseman, of what the stows represent.

In some stores, a piece of cardboard, tacked or pinned on to the stack, is the method adopted. Other stores use an ordinary tie-on label. Invariably, however, the first bag or case to be delivered is the one to which is attached the label or cardboard, and thus the stow has to be indicated afresh.

An idea to be seen in the more modern stores is a blackboard, approximately 3 feet by 2 feet, located at or near the chamber door. Painted on the blackboard is an outline diagram plan of the whole chamber, showing columns, etc., and with walls lettered East, West, North and South. It is then comparatively easy for the foreman or chamberman to chalk on this diagram the situations of the various stows, and to make what might be the almost continuous alterations needed to keep it up to date. Indicator boards have, however, certain disadvantages. Mischievous and irresponsible chambermen have been known to alter the chalk markings. The condensation that collects at chamber doorways tends to smudge and obliterate anything chalked on them.

A chamber diagram book, kept by the foreman, is a better idea. The book need be only the size of a pocket book with a page for each chamber. The

outline of the chamber can be roughly drawn in pencil, and the stows indicated in a manner similar to that used on an indicator board.

Most store foremen and chambermen pride themselves on their memories and scorn the use of either boards or books. In a large store, however, and very often, even in a small store, this is impossible. In any case, store managements prefer actual records to good memories.

Indications of chamber stows, accurately recorded and kept up to date, cannot be too strongly recommended. " Carry overs," or items not delivered because of errors, are far too common. These occur only because of faulty

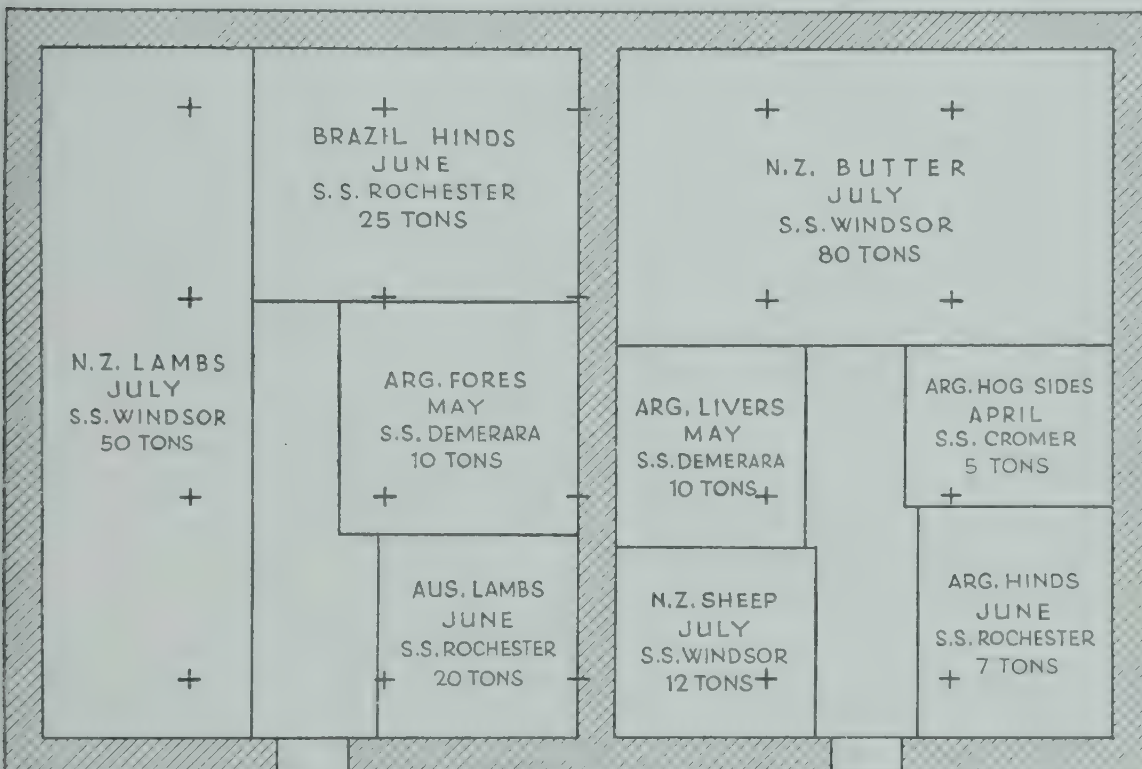


Fig. 18.—Chamber Stow Indicator Diagram.

indication and labelling, and are definitely due to carelessness. A " carry over " is an item that remains in store too long.

Anything that remains in store over six months, especially meats, develops store staleness. Store staleness develops mould, and mould is an infectious disease—it spreads.

Markings of stows and indications of stacks, together with account records, are essential. The chamber book in conjunction with the 6 in. blackboard is, and has been proved to be, the best system.

The blackboards above each stack in each chamber are the responsibility of the charge hand chamberman. The chamber diagram book is the responsibility of the foreman. He will need this on his person because of necessary constant reference, and for this reason it is in the form of a pocket

book. A larger and fair copy will, however, be kept in the office by the stock clerk.

CLEANLINESS

All chambers should be kept swept and this should be done, in addition, immediately after any delivery or intake. If this is not done, chambers will soon appear dirty and neglected. The most satisfactory scheme is to detail one man to each chamber, and to make this man personally responsible for that chamber. In some stores, the stacking gangs are lettered—" A " gang, " B " gang, and so on. The chambers, if there are many of them, will then be split up into groups corresponding to the same letters, so that " A " gang will clean the " A " group of chambers and so on.

The floors of chambers can get amazingly dirty. Wooden floors are most difficult to keep clean. Dirt, dust, straw, and blood, together with paper, sacking, bits of wood, and so on collect tremendously. When sweeping the chambers, any blood spots should be immediately removed. Difficulty will be experienced in removing congealed blood. If the floors are of concrete, a thin cement wash should be used over the blood stain. If floors are of wood, scraping and afterwards cleansing with a disinfectant is the only method possible. A thin dusting of lime over wooden floors is strongly recommended. Mould clings to wood, and germinates rapidly in old blood.

Odd pieces of meat which may have fallen from bags or cases should not be allowed to collect in chambers. A special box or portion of chamber for containing these oddments is useful. They can be sorted, collected, and a special delivery made at a later date.

VERMIN

A systematic examination for signs indicating the presence of vermin should be made daily. Corners of chambers, particularly at wall and floor fillets, are the usual places to show signs of droppings. If any are seen, then look for a hole in the insulation. If no hole can be found, then the nest is sure to be inside a carcase or case. Once inside a store, rats and mice if left undisturbed will soon overrun every chamber. The rate of multiplication is extremely rapid.

In searching for vermin, one must look for the nest. Old type stores often used timber for their walls, floors, and ceilings. Vermin can easily nibble through wood. New type stores use a cement facing on top of the cork, but this is even easier for mice and rats to attack. A few stores have used brick or tile facing. This is not at all unattractive, and can be whitewashed or distempered. The cost is not heavy, and it is definitely more vermin proof than either timber or cement:

Tracing and sealing vermin runs through the insulation can be a very lengthy and costly business, especially if the insulation has been erected in the envelope or curtain wall style. Brick or tile facing appears to be the answer to the vexatious problem of vermin.

Many stores make a payment of threepence for every rat or mouse caught. Once the presence of vermin is known every step possible should be taken to get rid of the pest. It is a good idea to appoint one of the staff as official rat-catcher and to pay him a small weekly sum. But for every rat or mouse seen inside the chamber made a deduction of threepence. This may be an unorthodox method, but it is usually very effective.

CHAMBER INSPECTION

Summarised, the duties of a foreman in his supervision of the work in a cold store chamber are very many and extremely varied. In addition to maintaining the well ordered, easy, and never faltering rhythm of handling work during intakes and deliveries, he must see that all the necessary separations of stows, as previously outlined and enumerated, are well maintained. At the same time he must pay due regard to the importance of leaving gangways, separations between stacks, and separations between each layer of each stack, in order to allow free passage of air. And he must never lose sight of the fact that every cubic foot of unused insulated space entails a loss of revenue.

In addition to this work, the cold stores foreman will have as one of his daily functions, which must never be omitted, the regular inspection of all chambers under his charge. This regular inspection takes the form of a daily walk through every one of his chambers. Chamber inspection, done thoroughly, can take all day. The stores foreman lacks the time for this, of course. He will not be able to take more than an hour at the most, and during that time interruptions will probably be many. He will walk through each chamber systematically, knowing exactly what to look for. Temperature, smell, dunnage lay-out, stowage, air circulation, thickness of snow on pipes, cleanliness, vermin, condition of commodities—all these will be the main points of his inspection.

Most experienced cold store men can ascertain the temperature and sweetness of a chamber as soon as they enter. One glance is sufficient for inspection of dunnage and stows, thickness of snow on pipes, and air circulation. The inspection of commodities will usually be limited to the inspection of one bag or case from the oldest stow. From five to ten minutes in each chamber is the average duration of each inspection.

Is this sufficient ? Yes, providing that the manager or foreman, or whoever it is making the inspection knows exactly what to look for, and where to look.

TEMPERATURE AND HUMIDITY

Of fundamental importance in cold storage are temperature and humidity. This is clear in the case of temperature, and there can be no better way to stress the importance of humidity than by saying it is equal to that of temperature. We shall see later that excessive dampness is favourable for the growth of mould, while excessive dryness causes the shrinkage of various commodities—especially those with a high water content. It must also be

realised that temperature and humidity are closely related : it is impossible to change the one without affecting the other.

To put it simply, warm air has a greater capacity for water vapour than cold air. At a given temperature air will absorb water vapour until it is saturated and can absorb no more. If the temperature rises, the air will immediately start to absorb again until it is once more saturated. If the temperature falls the air will be supersaturated and condensation, or dewing, will result. Various authorities assert that the air over the Sahara Desert sometimes contains more water vapour than the air over London in a thick November fog ; but its humidity is very much lower because hot Sahara air is able to hold a great deal more water vapour than can be held by cold London air.

It is thus seen that humidity cannot be expressed simply as the quantity of water vapour in a given quantity of air. Instead, the vapour present must be expressed as a percentage of the maximum possible amount which can exist in the air at the time of observation ; this maximum being, of course, conditioned by the temperature.

Thus, although the actual amount of vapour present in the air may remain constant, the relative humidity will vary with fluctuations of the temperature. A rising temperature will lower the humidity ; a falling temperature will raise it ; if the temperature falls far enough the point will be reached when the air can only just support the vapour, and condensation commences. This point is called the dew-point ; it is, in other words, the temperature at which the relative humidity is 100, for the air is then containing 100 per cent. of the vapour it is able to hold at that temperature.

It will be seen eventually that for most cold storage commodities the best humidity percentage is round about 80. Expressed otherwise, whatever the temperature at which the goods are held, the chamber air must contain water vapour equal in amount to 80 per cent. of the maximum possible for it at that temperature.

It may seem from the foregoing that the measurement of humidity must be a formidable business, but, in fact, instruments are available which render it a matter of simplicity. These instruments are known as hygrometers, or psychrometers, and are of various types. The commonest types are the wet- and dry-bulb thermometer, and the hair hygrometer.

The wet- and dry-bulb thermometer consists of two ordinary thermometers mounted together on a board. The bulb of one of them is surrounded by a piece of muslin, or lamp-wick, the free end of which dips into a small cup containing water. The water, of course, soaks into the muslin and keeps the thermometer bulb wet ; hence the name "wet-bulb thermometer." The other thermometer, the "dry-bulb," has no attachments. The instrument depends on these principles : (i) that evaporation causes cooling, (ii) that evaporation proceeds rapidly or slowly according to whether the air has low or high humidity. Thus, if the air is dry the water will evaporate quickly and the wet-bulb will be considerably cooled ; therefore, the greater the difference

between the wet- and dry-bulb readings, the lower the humidity. If the air is humid, water will evaporate slowly and the wet-bulb will be only slightly cooled ; therefore, the less the difference between the wet- and dry-bulb readings, the greater the humidity. When the two readings are identical the air is saturated.

To avoid the necessity for the laborious calculations of humidity which would otherwise arise in the case of the wet- and dry-bulb thermometers, tables have been constructed, and are available, which give the humidity directly for various readings of the thermometers.* The instrument will not be accurate unless the supply of water in the small cup is maintained and kept clean. The dry-bulb must be wiped if it shows signs of moisture condensing upon it. A good flow of air past the instrument is also essential.

The hair hygrometer, although it cannot claim the accuracy of the wet- and dry-bulb thermometer, is certainly more convenient and is probably more widely used in cold stores. Hair absorbs moisture readily, increasing considerably in length while doing so, and this property is the basis of the instrument. A bundle of hairs, usually seven in number and about four inches long, is kept tight by a small spring. Expansion or contraction operates a system of light levers and gears which move a pointer over a circular scale or dial. Humidity can thus be read directly without the need for calculation or reference to tables—a great advantage.

It has already been stressed that fluctuations in temperature cause corresponding fluctuations in humidity and in the moisture-absorbing capacity of the air. Since, for all commodities, there is an optimum temperature and an optimum humidity, it follows that the temperature must be kept as steady as possible. A storage temperature of 14° F. means 14° and neither 19° nor, at the other extreme, 10°. And 14° F. should be the temperature everywhere in the chamber, not just in one place. There are cold chambers where there is a temperature difference of as much as 7° between ceiling and floor, and between the ends of the chamber. Where such conditions exist there is obviously something wrong, and the need for more coils or air duct extensions is indicated. More than one thermometer is necessary in every chamber, and the mean of these thermometer readings should be taken as the actual temperature of the chamber. In addition to the mean of the various thermometer readings the average of the mean thermometer readings over the twenty-four hours should be accepted as the average temperature of the chamber. The condition of the commodities stored, and the "feel" of the chamber atmosphere reveal the temperature conditions. Steadiness of temperature is not only necessary but vital. Staggered short running hours of the refrigerating plant are far better than long runs alternating with long shut down periods. The extremes of the range of chamber temperatures—*i.e.* the highest and lowest points—are more significant and tell a more truthful story than the actual average temperature.

* See Appendix .

SMELL

Smells in chambers arise from various causes. Dirty hessian wrappers damp atmosphere due to too low a brine density in the brine coolers, or t pipes too thickly encrusted with snow. Quick lime, and ozonizers, are grea cleansers but it is, of course, necessary to find the cause of the smell an of the damp atmosphere, and to prevent a recurrence of them. Lumps of quick lime placed inside the air ducts are advisable. Powdered lime mixed with disinfectant and sprinkled on the floor will also tend to sweeten the air.

PURIFYING AIR IN CHAMBERS

Purifying air in cold store chambers by introducing ozone is not a new idea. Ozone was detected one hundred and sixty years ago. Considerable research work has been carried out and it is now defined as an allotropic form of oxygen containing three instead of the usual two atoms to the molecule. It is this extra atom which gives ozone its valuable oxidising character.

The use of ozone is far from being so general as it deserves to be. Ozonizers are rapidly becoming recognised as necessary cold store equipment in many countries, but in Britain conservatism dies hard. Traditionally, cold store practice does not yet recognise ozonizing equipment as being vital. Nevertheless —the more modern stores in Britain are installing ozonizers—particularly in fruit and egg stores, and the results obtainable are such that it will be only a matter of time before all cold stores will install one or more ozonizing machines.

The use of an ozonizing machine is to be recommended in all cold stores. It provides the most effective, cheapest, and quickest means of cleaning a chamber and clearing away bad smells and other pollution. Fresh air has sunlight to rejuvenate it, and to destroy germs. Ozone has proved to be equally as effective as sunlight for this purpose. It removes or prevents the possibility of foodstuffs becoming tainted by odours. If foodstuffs have inadvertently become tainted—for example, if orange taint has penetrated a beef or egg or butter chamber—a few hours running of the ozonizer will remove all traces of the taint. It will destroy mould spore and restore freshness. It will take away chamber staleness and prevent decay. It destroys surface bacteria, prolongs storage period, and in general considerably helps towards a much better out-turn of goods from cold stores.

There are two types of ozonizing machines—plate and tube. In general, the principle is an electrical discharge bombarding the air molecules. This bombardment causes combination of the oxygen molecules to form ozone. The machines are portable—can be carried from chamber to chamber and plugged into a light socket. Consumption is small, and an hour's running every day in a chamber will keep the air fresh and sweet.

THE "FEEL" OF A CHAMBER

When a cold stores man speaks of the "feel" of a chamber he means the general impression of the state of the air which he gains on entering the chamber. If he is experienced he will be able to tell whether the air is too humid or too dry, whether it is passing through too rapidly, and whether it is circulating freely throughout the chamber. He will probably be able to form some idea of the temperature difference between the air-inlet and the air-outlet.

All these factors are important because chamber conditions can change from day to day. Stacking can interfere with air circulation. Suction slides may inadvertently be shut, and delivery duct slides may be closed by a chamber gang working underneath them, and not opened again. Brine density may be allowed to get too low, and the circulating air will develop a saturated feeling. On the other hand the over-efficient engineer may increase his brine density too much and the commodities in the chambers will then tend to become shrivelled. Air circulation always needs watching.

In pipe-cooled rooms, direct expansion and brine pipes can acquire a nice thin flaky deposit of snow or a thick hard encrustation with a shiny, wet surface. Sometimes, all that is visible is a solid bank of snow hiding all semblance of shape of pipes and coils. The only correct state of affairs is the first of these—a thin, flaky snow deposit. Obviously, heavy snow deposit prevents good temperatures and sets up a humid atmosphere. Snow must be prevented from becoming too thick. Pipes must be cleaned or "snowed down" regularly.

COMMODITY INSPECTION

The appearance of beef in the frozen state, whether boneless or bone-in, gives certain clues from which age, health when alive, sex, etc., can be judged. These clues are valuable, because if the meat is in for long storage, certain changes in appearance after three and after six months' storage can be attributed to the animal, and not to the conditions of storage.

Heifer beef is usually closely grained, and inclined to be dark in colour ; the bones are small. Bull beef is coarse and very dark. If the fat is very fibrous and inclined to be yellow, the meat is not G.A.Q. (good average quality). Heifer beef quarters will be smaller than steer beef (steers averaging 8 cwt. against 5 cwt. for heifer). Examine the muscles—the paler the colour, the younger the animal.

Signs of store staleness show first at the ends of the quarters. The meat shows a brown shrivelled appearance. Cutting into the ends with a penknife will reveal the depth of the staleness. Usually it is not more than a sixteenth of an inch deep. If such a condition is apparent after only a short time in the store, then there is something wrong with the cooling of the chamber. The atmosphere of the chamber is too dry, and the meat is shrivelling and perishing.

Mould spots will show first on the underside of the meat—particularl
in boneless packages, where the meat has been folded over and the bloo
allowed to settle. In bone-in quarters, look for mould spots on the undersid
and also on the flanks.

What appear to be white mould spots, often show up under the torchligh
to be suet. Nevertheless, such spots should be examined minutely and wher
there is the least doubt the package should be taken out of the chamber an
examined in daylight. Black spots, of course, can only be mould, and th
depth of the penetration or growth, and the extent of the spread, should b
ascertained immediately.

CHAPTER 7

GENERAL WAREHOUSING

COLD storage warehousing, whether for storage and chilling of meats, dairy products, fruits and vegetables, follows pretty much the same pattern in all stores. Part of the refrigerated space is capable of maintaining storage temperatures from 12° to 16° F. The remaining space is devoted to chill chambers used for the storage of fruits and vegetables, etc., at temperatures ranging from 28° to 40°.

There are exceptions, of course. A few stores are devoted solely to chill storage, and business in such stores is reserved exclusively for chill goods, eggs, and fruits, and so on.

Other stores conduct warehousing purely as a side line, their principal business being the storage of some particular commodity for which they act as distributing agents, sales depots, or packers.

Several stores have chambers for the storage of products they are manufacturing or processing, such as ice cream, bacon, hams, etc.

Cold storage warehousing is generally confined to the warehousing of two classes of commodities—storage of goods in a frozen condition, and storage of chill goods or goods requiring a temperature slightly below that of the atmosphere.

Of storage commodities, the principal goods are meats, bacon, butter, poultry and game, and fish. Of chill room commodities, eggs in shell, and fruit and vegetables easily take first place. Meats are, of course, chilled after slaughter, but such business is usually confined to stores adjacent to an abattoir.

Pork products and ham and bacon factories usually have chill rooms as part of their factory layout. It is only occasionally, however, that in such stores general warehousing is catered for.

Many cold storage warehouses are installing one or more chambers specially for the storage of sharp-frozen packeted foods. Such chambers must be piped sufficiently for the obtaining and maintaining of zero degree temperatures. Such rooms are within the category of freezers.

Cold stores catering for general warehousing fall roughly into seven classes. There is the inland store, the port store, the market store, the abattoir store, the ice factory store, the ice cream store, and the specialised store. Operation in all of them is conducted as already described, but due to the special characteristics of the particular business for which they are designed, certain departures from accustomed practice must of necessity be expected.

THE INLAND STORE

The cold store serving inland districts is perhaps the best example of the store practising general refrigerated warehousing. An inland store is not usually a large store : one hundred to two hundred thousand cubic feet capacity

being the average. The daily movement, and the variety of commodities handled are, however, in comparison, rather heavier and greater than is customary with stores of this capacity range in other classifications. The chambers are generally of small capacity, being not more than fifty tons, and the need for separations is manifested by the number of clients storing goods. Shipments are received by road vehicles and, incidentally, the yard or entrance space is seldom sufficient.

The proportion of storage to chilling space averages 70 to 30 per cent. During the winter months the chill room space is empty more often than not. The " all the year round occupancy " percentage of the storage rooms space is seldom more than 50 per cent. During the summer months, of course, the occupancy percentage may rise to as much as 90 per cent.

Goods are seldom in store for long periods. Movement is greatest at the week-end, and a large proportion of the traffic is for two- and three-day storage periods only. The commodities handled cover a wide range and the store clients are usually the principal food distributors of the district—the butchers and provision dealers. A certain amount of fish is also handled.

THE PORT STORE

The store situated in a port area, at or near to the docks, is more often than not a refrigerated transit shed. Because of its locality, the main function of a port store is to receive goods ex ship pending allocation to up-country distributing centres. The capacity of such a store is usually large, and the traffic and movement rather heavy. Operating a port store calls for a high degree of handling skill. Chamber work must, of necessity, be rapid, and must involve methodical stowage so that correct separations are made, while at the same time making fullest possible use of the insulated space. Careful deliveries are called for, the rectification of mistakes being impossible.

Due to the considerable daily movement the refrigeration demand is heavy, and the heat losses excessive. The wear and tear on floors, lifts and trucks is far more than at other stores, and strict and thorough maintenance must be kept up.

Commodities handled in the port stores are principally meats. The checkers and chambermen should have an extensive knowledge of the different marks and cuts. Both in receiving and delivering, the ability to recognise at a glance the type and nature of the meat being handled is necessary, otherwise the speed of handling is badly affected.

THE MARKET STORE

The store catering for the " returns " or left-overs of the stocks—such as fruit, vegetables, and fish—of stall holders in public markets, both wholesale and retail, is not usually a large capacity store. Capacities vary, but range from 50,000 to 150,000 cubic feet. Many are built beneath the market itself, others are adjacent.

The principal asset of a market store is its proximity to the market. The intakes and deliveries are mainly conveyed to and from the store by local porters, and lorries or other vehicles are seldom used.

The operation of stores such as these presents problems slightly different from those in stores of the other classes. Close stowing is seldom possible, the separations are many, and great use must be made of racks in the chambers. Long storage is seldom requested, the turnover of stocks being rapid. Commodities are never handled in bulk, market cold storage being a small parcel trade, the clients and customers being numerous, but the extent of their business small. However, the combined tonnage of numerous small customers is heavy, and the value of the day's movement is high.

Every description of pack will be used in a market store, and the chamberman will have to exercise ingenuity and skill in stowing goods so that they can be found easily. Every case, bag, basket, carton, will have to be labelled, and the checker will be kept fully occupied.

A great deal of the trade in a market store is on a cash basis. The system of booking goods in and out will have to be tied up with a cash receipt system, *i.e.* a pay on delivery of goods method, the number of the cash receipt and the number of the delivery ticket being identical.

Working hours will be adopted to suit those of the market, business usually commencing very early in the morning and closing correspondingly early in the afternoon. There is little night overtime.

THE ABATTOIR AND MEAT MARKET STORE

Meat chill rooms are a feature of all abattoir cold stores. They are high, narrow rooms, fitted with hanging rails. As animals are slaughtered and dressed, the carcases and sides are hung in the chill rooms, usually for 48 hours. From the chill rooms they pass direct to the market for immediate sale.

The rest of an abattoir cold store is similar to any ordinary cold store, and the trade is on similar lines. The chill rooms, and perhaps two or three storage rooms reserved for storage of meats ex abattoir and the meat market " returns " or left-overs, represent the main departures from general cold storage warehousing.

Meat chill rooms and the chilling of meat will be dealt with in the section dealing with this commodity. " Returns " or left-overs from the meat market require little special treatment beyond the work of laying out the quarters and cuts on the floor or on racks for hardening. Naturally, warm defrosted meats cannot be stacked in chambers otherwise they would stick together. Returns must therefore be laid out separately until they are frozen. Long storage of " returns " is never required, nor would it be advisable.

COLD STORES WITH COMPOSITE BUSINESS

Cold storage warehousing is frequently combined with the manufacture of ice, ice cream, and mineral waters, with haulage, with the distribution of

coal or other commodities, and with the sale of household refrigerators and so on. In such cases, refrigerated warehousing is generally the main business, and the other a mere subsidiary. Sometimes, however, the reverse is the case. It frequently happens that the combined businesses have opposing seasonal peaks ; in summer, refrigerated warehousing will absorb the main attention of the personnel, and in winter, the greater part of their energy will be transferred to the subsidiary business.

Ice manufacture has declined of late years, owing to the increased use of household and small commercial refrigerating units. The demand for these small units originated from the smaller principal customers of ice manufacturers, such as hotels, markets, shops, and hospitals. Nevertheless, there remains a considerable number of ice users, and ice manufacture is still necessary. The combined ice factory and general refrigerated warehouse is still very much in evidence.

Ice cream factories combining their business with refrigerated warehousing are developing into the rule rather than the exception. They differ from ice factories only in the disposition of the staff. With ice factories refrigerated chambers are necessary for the storage of ice. With ice cream factories, chambers are necessary for the storage of ice cream, but freezing rooms are, in addition, an integral part of the manufacture. The labour employed at an ice factory would be engaged on all sides of the business. When not engaged in lifting, storing, and delivering ice, the men would be employed in the refrigerated warehouses attending to the receiving, storing, and delivering of cold stored goods. In an ice cream factory there are usually two separate staffs, men or girls, or both, concerned only with the manufacture of ice cream, and men for the actual cold storage warehousing work. The ice cream would be received in the freezing chambers, and later transferred into the storage rooms by the warehousing staff. The freezers would be chambers specially piped to obtain and maintain the lower temperatures.

In food factories producing foods, such as bacon or ham, or processing foodstuffs for the marketing of special brands, refrigeration is largely employed, and refrigerated store rooms are necessary for the finished or processed articles. Occasionally, such factories have surplus refrigeration and empty chambers. In an effort to make use of this surplus, and if the local demand is great enough, ordinary general refrigerated warehousing will be catered for, until it becomes a regular feature of the business. In such catering, the cold storage operation will not differ from that practised, as already outlined, in the average store.

There are also cold stores built specially for the refrigeration and storage of one special commodity, such as for eggs, fish, fruits, pork products, etc. The operation of such stores, and the design and construction of the chambers, is governed by the peculiarities of the commodity handled. Storing conditions, stacking and chamber work will also vary. The system of receiving and delivering, however, remains much the same for any commodity.

GENERAL

The location of cold stores will be governed mainly by the distribution of population, but there are many other factors to consider. The following table is of interest :—

POPULATION WITHIN DIFFERENT RADII OF LARGE TOWNS

	100 *miles.*	75 *miles.*	50 *miles.*	25 *miles.*
London	16 millions.	14 millions.	12 millions.	9 millions.
Manchester ...	18 ,,	16 ,,	10 ,,	4 ,,
Birmingham ...	12 ,,	6 ,,	3 ,,	1 million.
Hull	13 ,,	7 ,,	2 ,,	$\frac{3}{4}$,,

Britain's millions are centred in and around the ports, in the Midlands, and in the North West. In London itself there are 23 million cubic feet of refrigerated space. Birmingham, however, with three million people within a 50 mile radius, has less than one million cubic feet.

The positioning of refrigerated warehousing facilities is governed not only by density of population but also by the nearness of traffic centres, and to junctions, and termini. It began first of all at the ports ; the inland stores came later.

The prosperity of the refrigerated warehousing industry depends principally on the seasonable availability of foodstuffs coupled, of course, with the price. The majority of foodstuffs are produced each at a particular season. During the months of production such foodstuffs are plentiful and cheap. Throughout the months of non-production there is a scarcity and the price is high. It thus becomes a simple matter to calculate whether the cost of refrigeration necessary to store surplus products until the non-producing season can be met by the difference in the price realised.

Chickens are plentiful in the autumn months, eggs are produced in great quantities from March to June, fruits are available in the summer. Palatable fruits obtainable in winter, eggs at a fairly reasonable price at Christmas, and chickens on sale in summer are all possible—but only by refrigerated warehousing. Thus from March to June, there is a demand for cold storage space for eggs, throughout the summer months the chambers are required for fruits, and in the autumn poultry and game are stored. There is a demand for refrigerated space throughout the year, but the demand is greatest during the off seasons for certain products. The science of refrigerated warehousing is built upon the data and technique of foods, and their production and preservation. With refrigeration, foods of all descriptions can be obtained all the year round in perfect condition, and it is only by refrigeration that over production can be used to advantage, and prices kept normal.

CHAPTER 8

STORAGE OF MEATS

MAIN DIVISIONS OF MEATS

MEAT is the principal commodity stored in cold stores. For the purpose of refrigerated warehousing classification, meats have three main divisions: beef, mutton and lamb, and pork. But each of these main divisions can be subdivided and each of them is further described as either home-killed or imported.

Cold store operators should know something of the composition of the meats (and, indeed, of any other products) they handle. They should also be acquainted with the treatments which meats may undergo before arrival at the cold store. Refrigerated warehousing implies preservation, and the technique of preservation requires as many data and as much pre-knowledge as possible.

Three months is the usual length of cold storage period for meats but, dependent on circumstances, meats may stay in cold stores for six or twelve months, or even longer. The changing condition of meats during cold storage may be due to a variety of causes. The cold store operative should be sufficiently acquainted with the peculiarities of meats to be quite certain that any change in the condition of meats under his care is due not to defective storage conditions, but to the composition of the meats themselves or to treatment given prior to storage.

The cause of " off " meats discovered in cold stores is usually immediately attributed to store staleness, and the question of defective storage and of stowage is at once raised. The cold store manager must be able to refute such charges. Meats of an inferior quality will develop an " off " condition more quickly than first-class meats. It requires intimate acquaintanceship with the meat trade to develop the ability and experience to judge meats and their quality. Such intimate acquaintanceship is not readily available. It must be sought.

BEEF

Of the three main divisions of cold storage meats, beef easily takes pride of place and should be considered first as a raw material; breeding, feeding, environment, and climatic conditions being important factors in the development of quality, weight, and size.

Beef as a Raw Material

Usually home produced and imported supplies of beef are approximately equal. Refrigeration has been responsible for the increase in beef imports, and the difference between the quality of home killed and imported beef is gradually lessening. Home killed beef is put on the market for wholesale and retail distribution in a fresh condition. Refrigeration is not employed except immediately after slaughter when beef is hung in chill rooms for a period of from one to two days. Imported beef arrives either as frozen beef or as chilled beef. Frozen beef is beef which, after slaughter, has been frozen hard and the period between slaughter and consumption can be as long as six or seven months, and is very often longer. Chilled beef implies beef shipped immediately after slaughter, and kept in a chilled condition for the period of the voyage only. Chilled beef is put on the market immediately the vessel carrying the beef has arrived.

Cattle are bred and reared for the production either of beef or of milk and other dairy produce. Store cattle are reared for periods of between twelve and eighteen months and are then slaughtered for beef. They fall into three main classes according to their weight range, whether light, medium, or heavy.

At birth calves have short bodies and long legs. Matured beasts are judged for quality by their body conformation. The conformation that finds favour with buyers is a long body with short legs, well developed rump and loins, and a general stocky appearance. To develop this particular conformation, particular care must be given to feeding. There are special diets for fattening, and the care in rearing and feeding is important during the early months after birth.

In this country stock-rearing is probably the most important function of the agricultural industry. There are particular beef breeds, mostly named after the counties of their origin, and there is considerable cross-breeding going on all the time in order to improve quality. There is also considerable movement of cattle from one district to another. Grazing in different districts has a considerable effect on resultant quality. Calves are usually dropped, or born, in the winter months, and most farmers aim at rearing for two seasons, by which time they should be sufficiently developed for marketing and killing.

Light-weights supply beef which can be cut into small joints with little bone, the covering meat being exceptionally tender and palatable. Medium-weights show slightly more bone, and heavy-weights, of course, have more waste.

Although the demand for beef is always heavy, it is subject to seasonal variations ; in summer it tends to lessen, and in winter, when the weather is colder, it tends to increase. The fluctuation has its effect on production, and killings are fewer in summer. As killings decrease, the farmer is faced with the expense of keeping his store cattle a little longer, and he must make provision accordingly. He must endeavour in the following year to recuperate this extra expense by shortening the period of keeping his store cattle.

Conveyance to Cold Store

Cattle reared for beef production are usually ready for killing about the second year. In England, cattle brought to slaughter houses are classed as home killed beef, and do not usually go to cold storage except for, at most, a couple of days hanging in chill rooms. The beef passes direct to the wholesalers and to retailers for immediate consumption. Imported beef from Australia, South Africa, New Zealand, Canada, and South America is shipped either as frozen or as chilled beef.

To cater for their considerable export trade, ranches, abattoirs, and freezing houses abroad are on rather a large scale. The day's killing, and the daily freezing of carcases is heavy. The two sections of the trade, frozen beef and chilled beef, are kept distinctly separate, and different vessels are employed for the two classes of beef. Carcases are divided into hind and fore quarters, are wrapped in white cloths and hessian wrappers, placed on board ship in the refrigerated holds, and the ship's engineers, once the holds are battened down, maintain the desired temperature until the ship arrives at the home port and the beef is transferred from the holds to the waiting vehicles, and conveyed to the store.

During treatment after slaughter and during conveyance from the abattoir to the cold store many things may happen, the effect of which can be seen only after the beef is in the cold store. Poor temperatures in the ship's hold, dead pockets and indifferent air circulation, delays at the port of discharge and the port of despatch, odours transmitted to the meat from previous cargoes, careless packing house practice, and so on.

Modern packing house or abattoir practice is usually beyond reproach. Transport by sea, rail, and road is very different from what it used to be, and it is only rarely that meats are damaged in transit. The causes of decomposition in meats can usually be traced. Bone taint cause must be looked for at the abattoir, odours and contamination are usually traced back to the treatment prior to receipt at cold store, and pre-defrosting is indicated by the state of the wrapper. If the wrapper has any blood stains when the meat arrives at the cold store then defrosting has taken place at some stage during the journey.

Composition of Meats

Steer and heifer carcases are split into sides. The sides are divided as shown in Fig. 19. The principal parts of a side of beef are: neck chuck, fore shank, rib, plate, loin, flank, rump, round, and hind shank.

Each part of a side of beef or carcase is composed of muscle, connective tissue, bone, and fat. From a cold storage point of view, fat is the most important. Fatty quarters keep better in refrigerated chambers. Marbling, or the mixture of lean and fat, is an indication of good quality beef. Poor carcases have little marbling, and the meat is stringy. Fat globules are cells of oil which give added flavour to the meat.

A steer or heifer before slaughtering has a certain weight. After slaughter and dressing, the weight will, of course, be much less. The dressing weight percentage of the live weight varies with the quality of the beast. Fifty per cent. of the live weight represents the average dressed weight.

The composition of this dressed weight is important to the cold store operative. He has to freeze this weight and to hold it frozen. And it is in reference to this composition that the quality descriptions of beef have so much meaning. The four descriptions are usually thin, medium, fat, and very fat. For each of these qualities the composition of the meat is different.

About 50 per cent. of the dressed weight of the average carcase represents water. The water content of any carcase varies with the degree of fatness. The leaner the meat the greater the percentage of bone, with a corresponding decrease in the percentage of edible meat.

There are five customary qualities of beef: prime, choice, good, medium and common. But according to the country of origin there are slight variations of the above classifications. In England, the five are reduced to three, and are termed select, prime, and good. The United States have four: prime, choice, good, and medium. South America also has four, and marks the wrappers, A.1, A, B, and C. More often, however, these four South American classes are reduced to two: selected premier and premier. Australia classifies her beef as either G.A.Q. or F.A.Q.—good average quality or fair average quality. New Zealand has three qualities—prime, 2nd quality, and 1st quality.

Compared with one another, these classifications can be set out as follows:—

England .	Select.	Prime.	Good.	———
U.S.A. .	Prime (A.1).	Choice (No. 1).	Good (No. 2).	Medium (No. 3).
S. America .	Select Premier A.1.	Premier. A.	B.	C.
Australia .	G.A.Q.	———	F.A.Q.	———
N. Zealand .	Prime.	2nd quality.	1st quality.	

Prime beef is the very best beef. Produced from the finest selected type of cattle, fed on the best cattle food, and reared under the best conditions. The carcases are from young beasts of under three years, perfect in conformation, finish, and grain. Such carcases are usually those of steers, with occasional heifer carcases, but never are they of cow or bull.

Choice beef is the next best grade and comes from beasts of good breeding and rearing—mainly steers. Carcases show slightly more fat than prime.

Good beef, sometimes known and stamped as No. 2, is better beef than the average, and has the characteristics of prime and choice, but is rather coarser in grain and has predominant and excess fat. Produced from steer, heifer and cow, and also bulls.

Medium beef—that is, No. 3—is average beef. The flesh is of average thickness, and the fat is well distributed. The weight range is lower than in the preceding grades, being as low as 350 lb., as compared with 450 lb. in the No. 2 grade.

Common beef—that is, No. 4—is old, thin beef from poorly fed cattle. The fat is yellow, and the flesh poorly grained. It is produced mainly from cows.

Judging beef from appearances, the upper grade range of beef can be determined by the thick loins, deep rounds, well fleshed ribs, and the thick flanks. Thin rounds and shallow loins denote the lower grades. Upper grade beef proves good breeding and feeding, and the meat is tender, succulent and with little bone.

Where fat is white and flaky and well distributed, the carcase can be described as having a good finish. Bunched fat and kidneys and muscles show a poor finish, as do uneven distribution, poor marbling, or soft yellow fat. Where the quarter or joint of beef is too small to reveal the conformation, the appearance of the fat provides the clue to the quality of the beef.

It should be understood in judging meats that there are four factors producing a quality beef. They are breeding, feeding, sex, and age. Look for firm, well developed muscular tissue, with plenty of fat between the muscle fibres giving, at first glance, a distinctly marbled appearance. The grain should be fine, and with a bright red colour.

Receiving at Cold Store

Bone-in beef is sent into cold stores either in quarters or cuts, and boneless is wrapped in cloth and hessian wrappers, or—if in cuts—packed in cases or cartons. It is received from abroad either in a chilled or frozen state.

The marks on cloths, wrappers, or on the beef itself, vary according to the country of origin, and the particular shipper. The classification is sometimes in full words—" Prime hind ", merely letters—" G.A.Q. Fore ", or as numbers —" No. 1."

The letters " X," " H," or " C " refer to ox, heifer, or cow. The abbreviation " Mftg" denotes that the beef is intended for manufacturing purposes, being, for example, a poor quality beef not suitable for making into joints for the table, but quite satisfactory for making into extracts, moulds, and so on. Some shippers use red letters to denote manufacturing beef.

A study of the markings on wrappers will enable anyone to detect the country of origin at a glance as well as the quality of the beef. In addition, it will give more or less an immediate clue to the weight range. Good quality beef quarters are usually not more than 160 lb. The next class averages 180 lb., then not more than 200 lb., then over 200 lb.

There are certain reservations to the above weight ranges for cold-storage purposes. Ox hind quarters, naturally, are in a heavier weight range than cow hind quarters. Crops, usually from Australia, indicating a beef quarter with the brisket, flank, and shank off, will weigh so much less. In certain

nstances, numbers are used to indicate weight range. A code number is ccasionally used to indicate the quality of the beef, the even numbers indicating ood quality, and the odd numbers indicating poor average quality.

Experience and familiarity are required to enable cuts to be recognised at glance. Shape, of course, plays a big part in easy recognition. The more egular cuts are as follows :

Sides. Hind-quarters. Fore-quarters. Fore-quarters ex plate (flank). Fore-quarters ex plate and brisket. Rib and pony (fore-rib, chuck and blade). Crop (fore-rib, chuck and blade, clod). Fillets. Topside and silverside. Thick flank. Aitch bone. Rump. Loin. Thin flank, Shin and leg.

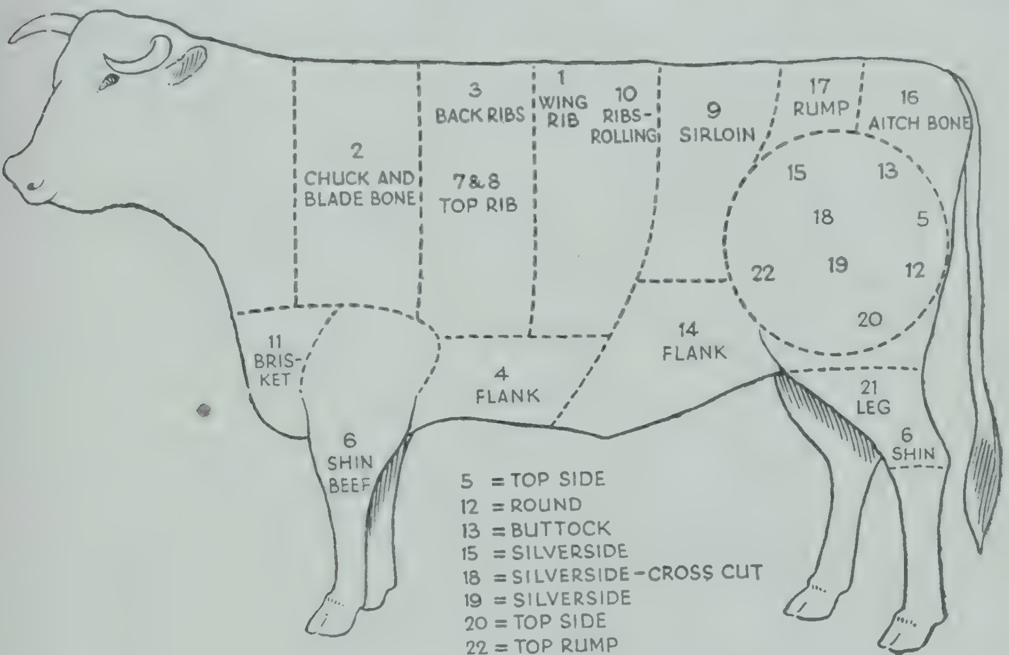


Fig. 19.—Parts of Beef Carcase.

Under the term offals are included :

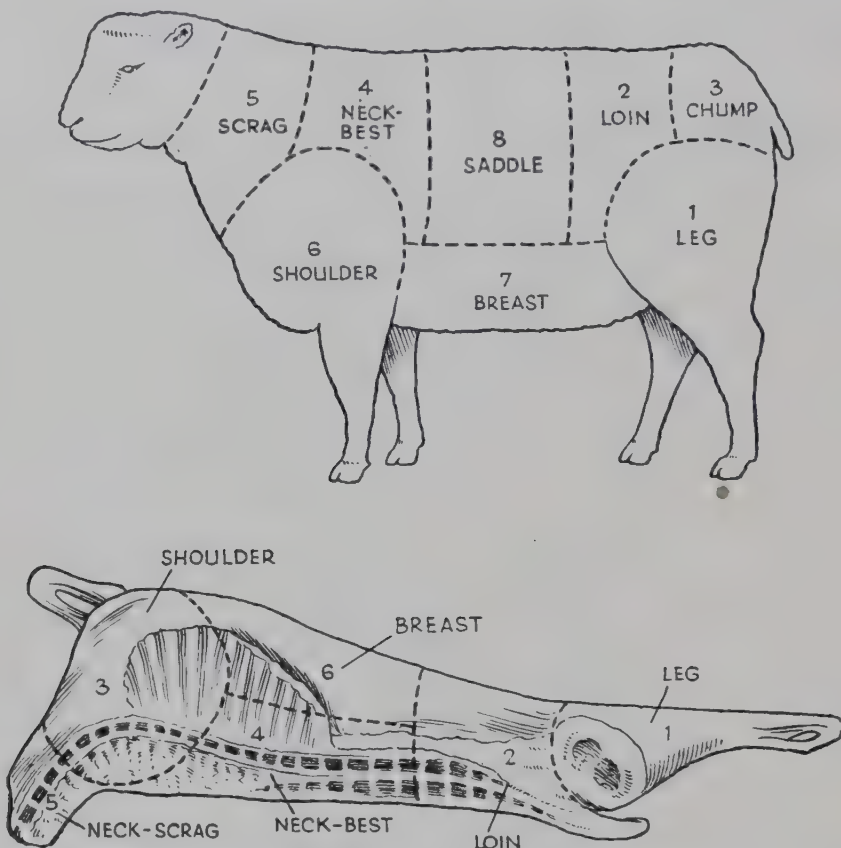
Liver. Heart. Head. Tongue (long and short cuts). Sweetbreads. Tail. Skirt. Cheek. Kidney. Tripe.

It is impossible, when receiving at cold stores, to examine all intakes, but ll meats are liable to damage during transit. A percentage should be examined. The usual rule is to examine one of every description and every pack. Soft meats, re-frozen meats, de-frosted meats, broken shanks, mis-shapen carcases must be sorted out and stowed separately, and a report made on each one.

LAMB AND MUTTON

The amount of imported lamb and mutton held in cold store far exceeds that of home killed. Cold stores are seldom asked to receive home killed lamb or mutton, but imported lamb carcases from New Zealand, Australia, and, lately, South Africa, are stored in their thousands.

Lamb and mutton are usually received as full carcases, minus heads of course. The dressed carcases are so small, in comparison with beef, that there is no necessity for cutting until ready for retail distribution. Cuts, sides, and legs are occasionally packed separately by different packers, but generally, the whole carcase is wrapped in a white cloth, and shipped complete. Lately, in order to economise in shipping space, the hind legs have been cut and inserted inside the carcase. When this is done the carcases are said to be telescoped. Carcases with legs uncut are known as straight carcases.



SIDE

Fig. 20.—Sheep and Lamb Carcase.

Age and weight distinguish mutton from lamb. Climatic conditions and feed influence the texture and sweetness of the meat. New Zealand lamb particularly is influenced for the better by the climatic advantages New Zealand enjoys.

Dressed lamb carcases average 30 to 35 lb. only in weight. When frozen, the carcases represent thin shells and it is this thinness that makes them susceptible to mould growth during long storage.

When cuts of lamb and mutton are received for storage they are most often packed in bags, but they may come in cases or cartons. The usual terms for the cuts are as follows:

Hind-quarters. Fore-quarters. Legs. Haunches. Loins and Saddles. Shoulders. Trunks. Short fore-quarters.

Sheep and lamb offals are termed :

Plucks and Melts. Livers. Brains, Hearts. Heads, excluding tongue and brains. Tongues. Kidneys. Fries. Sweetbreads.

PORK

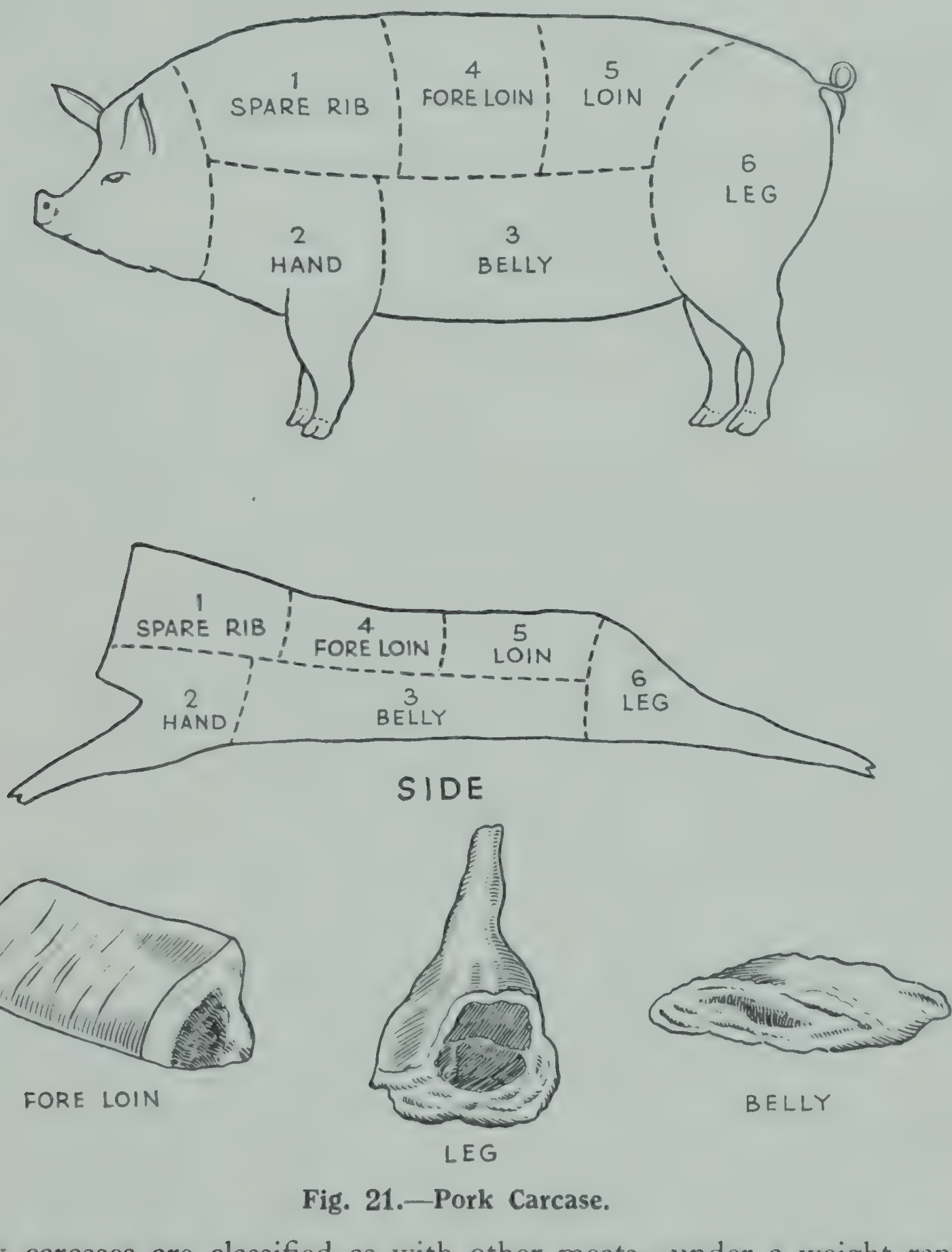


Fig. 21.—Pork Carcase.

Pork carcases are classified as with other meats—under a weight range—but this alone is hardly sufficient to define quality. Carcases differ from each other, and it is somewhat difficult to lay down standards of conformation and flesh texture. Frozen pork is the meat of an immature porker, and the class is usually that of a prime porker. Such a carcase weighs between 60 and 80 lb., the animal having been either a young castrated male or a virgin female.

Judging carcases inside a cold store chamber, the main characteristic[s] sought for are a good depth of loin, a straight back, an even thickness of fa[t] that is firm and white, short shanks, and the whole carcase clean and free from bruises and discolorations.

There are classes known as Class 1 (from 60 to 80 lb.), Class 2 (from 80 to 100 lb.), Class 3 (from 100 to 120 lb.). Above 120 lb. the carcases are always reserved for baconers. Each weight class is further subdivided into first or second quality.

Light weight carcases are known as porkers, medium weights as cutters, and heavy weights, as we have seen, as baconers. A baconer may be anything from 100 to 140 lb. dead weight.

Pork carcases in cold storage are also described as heads-on, or headless. Fewer carcases are sent to cold stores to-day. Pork arrives mostly in sides, and in cuts which are termed pork products. The sides are wrapped in paper and white cloths, the products in cases and cartons.

Pork cuts or pork products have fairly familiar names. The more regular are :

> Tenderloin, Loin, Middle, Trunk, Boston butt, Pork Shoulder, Picnic ham, and Trimmings. Pork Offals are described in practically the same terms as those of other meats.

VEAL

Little veal is seen in cold stores, but if and when it does arrive at a cold store it is seldom in cuts. Being small it is usually stored either as whole carcases or in sides.

STOWAGE

Bone-in quarters should be stowed so that the second layer lies crosswise with the first layer, and the fourth layer lies in the same direction as the second layer.

Bone-in beef quarters offer little difficulty and present few problems in stowing ; they should be stowed on 3 in. floor dunnage, with the flanks towards the gangways. There is no necessity for 'tween dunnage ; bone-in beef does not lie snugly together, and there will be plenty of airways in each stack, allowing maximum ventilation.

Experienced stacking gangs will easily stow bone-in quarters ten high. A hind-quarter of bone-in beef can be handled by one man if he is experienced in the art of pitching the quarter on his shoulder at the correct flank position. A good gang of eight men will stow eight to ten tons, or 150 hind-quarters, per hour, even under fairly difficult conditions. Their stowing will be tight enough to show an average of 115 cubic feet per ton.

Bone-in fore-quarters are handled in the same way, and will stow a little more tightly.

Boneless beef, or boneless pork, requires much more care. There is an ever-present danger that a boneless quarter may be in a soft condition, and, if stowed, will not harden and will in time putrefy and affect the other quarters. Close examination of each quarter is therefore very necessary when stowing, and any in a soft condition should be laid out separately, and not included in the main stow until thoroughly hardened.

Boneless meats, when stacked, will form a composite whole. The quarters will nestle into each other and prevent all ventilation and free air circulation. Dunnage of 3 in. by 3 in. on floors, and 2 in. by 2 in. between at least every second layer, is necessary, and should not be omitted.

The size of stacks depends upon the dimensions of the chambers. Even in large chambers, the stacks should not exceed 50 tons, or 1,000 quarters. A second stack should be begun with further quarters coming into store, and a space of at least eighteen inches should be allowed between each stack.

Boneless meats will naturally stow more closely than bone-in beef, and an average of 106 cubic feet to the ton can be maintained, even after allowing for 'tween dunnage.

Bags of offals, liver, hearts, ox-tails, etc., also stow fairly closely. Their condition should be examined carefully when receiving into store, and soft bags must be laid aside for hardening. The bags are small, averaging 40 to 50 lb. in weight. 'Tween dunnage is not always necessary, because the bags are fairly uneven, but it is generally advisable. Floor dunnage for bags of offal usually has to be laid fairly close owing to the smallness of the bags.

Kidneys are usually received in cartons. Liver is often packed in tins of ten pounds net weight, six tins to a case or carton.

Cased meats present few stowing problems. The cartons are usually good packs, but where there is any suspicion that thawing out has taken place during transit, the cartons should be watched carefully. Blood and condensation cannot drain away from the carton, and the carton itself acts as an insulant.

Separations

It will be obvious that hind-quarters should be stowed in a separate pile or stack from fore-quarters. Hind-quarters belonging to one customer must not be mixed with the hind-quarters stored for another. Hind-quarters received in October must not be mixed with the hind-quarters received in, say, July, even if both shipments are stored for the same customer. The same applies, of course, to fore-quarters and to all other meats.

In brief, correct stowage means as many separations as possible, so that any particular parcel may be found immediately, and the possibilities of confusion, mix-ups, and withdrawals of last shipments first, are reduced to a minimum.

Summarised, separations can be expressed as follows :—

Boneless beef must be separated from bone-in beef. The quarters or bags must be stowed according to their mark, country of origin, cut, date of receipt, and shipment.

Offals must be stowed apart, making the same four separations as abo In addition, offals received in cartons, cases, or tins, must necessarily ha different stows from offals received in hessian bags.

Lambs and Sheep Carcases

Lamb and sheep carcases usually arrive, as with pork carcases and po sides, wrapped in white cloths, commonly referred to as stockinet. Sto should be begun, on ample floor dunnage, with bellies up. Care should taken that no soft carcases are stowed. The sticking of lamb stacks is a freque occurrence: it is usually due to carelessness, stowing soft carcases, bad a circulation, etc. Condensation of moisture on the white cloths provides anoth means by which carcases may freeze together. The breaking apart of th carcases afterwards proves difficult, and results in damage and torn cloth

[*Courtesy*: "*Modern Refrigeration*"

Fig. 22.—Stacking of Lambs.

Dunnage can be easily broken, and stout iron crow bars bent, in endeavouring to effect separation.

Another form of stacking carcases is to lay the first layer bellies up, the second layer on the sides, the third layer bellies up, the fourth layer on sides again, and each time reversing heads and rumps. This usually makes a much more stable stow, and allows for ample ventilation.

Carcases are often received telescoped. The hind legs are cut off and the complete haunch is telescoped inside the loins. Shipping carcases this way saves shipping space, and telescoped lambs tend to make a very compact stow so that the stores "cubic feet per ton" figure is considerably reduced Carcases with legs on take more room but make a more airy stow, and the liability to stick is not nearly so great.

Lambs average 30 to 35 lb. per carcase, and range from 66 to 70 to the ton Stowing averages 90 to 95 cubic feet to the ton.

Sheep are naturally somewhat heavier, averaging 50 to 60 lb. each, 40 to the ton, and stow 100 cubic feet to the ton.

ork Carcases

Porkers arrive headless or with heads on. More often they are received cold store in the form of sides. There is also a considerable amount of oneless pork being received at present. As with boneless beef, boneless pork received in hessian bags, weighing 70 to 100 lb. to the bag.

Pork carcases and pork sides are usually wrapped in stockinet. In addition, articularly with the sides, paper wrapping is used also. Carcases and sides must be stowed separately. When sides are received in bales, two sides to a ale, a separate stow must be made of these also. In addition to these separations, nd the four separations as for beef and other meats, pork carcases and sides must be separated according to weight range. Usually those under 100 lb. must be stowed separately from those carcases or sides over 100 lb. Occasionally his difference of weight range is varied. The trade has different uses for pork arcases and sides, based mainly on light, medium, and heavy-weight ranges.

The stacking of pork, lamb and sheep carcases, and pork sides is easy in omparison with other meats. Carcases and sides are easily handled, and good entilation is ensured if the stacking is on the criss-cross method ; 'tween unnage is then not necessary.

WEIGHTS AND STOWING CAPACITIES

Bone-in Beef

Hind-quarters average 160 lb., or 14 to the ton, and stow 130 cub. ft. to the ton.

Fore-quarters average the same weight, but stow a little more compactly. For safety, however, allow the same conversion, and cub. ft. to the ton.

Boneless Beef

Bags average 70 to 125 lb., 17 to the ton, and stow closely at 90 cub. ft. o the ton. This, however, is too close, and with 'tween dunnage, over 100 cub. ft. to the ton will be found to be a safe minimum.

Kidneys

These are cartoned at 24 dozen per carton, 35 lb. net weight, 40 cartons or bags per ton, and stow at 100 cub. ft. per ton.

Livers, Ox

In bags or cases, averaging 40 lb., 39 to the ton, and take 100 cub. ft. per ton.

Livers, Lamb

In bags or cases, or cartons of six to ten lb. tins, average 60 to 70 lb., 39 to the ton, and stowing at 100 cub. ft. per ton.

Ox Tails

In bags of approximately 40 lb., do not stow too compactly, but average 100 cub. ft. per ton. Have the same conversion as other offal at 39 to the ton.

Hearts

Similar to ox tails in that they do not stow too compactly, are receive hessian bags, weigh approximately the same as ox tails, and have the s conversion and stowing figures.

Porkers

As carcases, headless, averaging 100 lb. in weight, 23 carcases to the t and stowing at an average 120 cub. ft. per ton. While an average 100 weight is given, carcases can vary from 90 to 130 lb. weight.

Pork Sides

These are naturally half the average weight of carcases. The same numb of cubic feet is taken up for stowing, and sides will vary, in conversion, fr 40 to 45 per ton, according to the weight range.

INSPECTIONS

Meats require frequent inspections while in store, and wrappings will ha to be torn open to inspect them and to examine the flesh for signs of sto staleness. It is customary to examine one or two bags in different parts of t chamber. Without pulling down the stack it is impossible to examine t bags other than those at the outside or on top. This is, however, usual sufficient. Evidence of torn bags shows that an eye is being kept on the meat A long, thin lath passed between the dunnage right to the centre of the stac is sometimes useful as a guide to conditions in the centre. Stacks near th doors and near the end walls, if accessible, should be watched carefully. Offal more than other meats, require particular examination.

CHAPTER 9

FROZEN PORK AND BACON

PORK AS A COLD STORE COMMODITY

It is a peculiarity of this country that beef and lamb are preferred to pork as the principal item for the main meal. Pork in its cured form, such as bacon and ham, is extremely popular for the other meals. The roast beef of Old England or the lamb or mutton for lunch or dinner—but, for an English breakfast, fried bacon or ham, and for an English tea, boiled ham.

Because of this, frozen pork does not figure largely as a cold store commodity. Pork carcases, pork sides, and pork products in comparison with other meats are a minor source of revenue. On the other hand, bacon and hams compare favourably with meats as a principal commodity in refrigerated warehousing.

The greater part of pork in cold storage is imported. Home killed pork meats fall under the description of fresh pork and go direct to the markets and into consumption. Imported pork, known as frozen pork, comes mainly from the Argentine, United States and Canada. South Africa and New Zealand also contribute.

Imports are usually at their peak during the winter months, and on the classification of these imports depends to a large extent the intakes of pork into refrigerator warehouses. Imports are in the form of carcases, sides, and cuts such as loins, hams, butts, and shoulders. Classification is into three grades or weight ranges: Class 1—60 to 80 lb., Class 2—80 to 100 lb., and Class 3—100 to 120 lb. Anything above 120 lb. is outside the classification, and such heavy carcases are known as baconers. Each classification is divided into two grades for quality: Grades 1 and 2. Pork differs from beef and mutton in that there are not the varieties of carcase conformation and of flesh texture. The quality of pork depends mainly on body structure and on texture of both lean and fat meat, together with the usual freedom from bruises, blemishes, and malformations of any kind. It also depends on good length and on straightness of back, with a correspondingly good depth of loin. The rind should be thin. The carcase should be that of a castrated male or of a virgin female. These characteristics are those of a prime porker. Class 1—60 to 80 lb. weight range—Grade one for quality.

DISTRIBUTION OF PORK

Home killed pork and imported pork (including the offal) are first han by the wholesalers, who usually deal in whole carcases. These whole carc are sold as such direct to the retailers, but there are secondary or intermec wholesalers, who buy whole carcases for the purpose of selling cuts and o to curers and speciality wholesalers. When whole carcases are sold direc a retailer, the retailer is usually in a position quickly to dispose of both carcase and the offal to his customers.

Cold storage is seldom required for home killed pork except for retu from the wholesale market, in which case the cold storage period is very sh Cold storage is required only for that period which sometimes, but not alw elapses between slaughter and consumption. As with beef and other me the home production is always adjusted to that of demand so that long per storage is never necessary.

The cold storage of imported pork is necessary only because it is impossi to adjust the arrival of ships exactly to suit marketing requirements. such periods therefore as are necessary between arrival of imports and adjustment of market demand, price stabilisation and transport regulation, cold storage of imported pork supplies is both customary and usual.

The greatest use of cold storage for pork, however, is in the holding conservation of pork set aside for curing and the needs of the bacon tra It follows therefore that the bulk of the pork seen in cold stores comes un the baconer class. Also, it is mainly with the bacon trade that refrigera warehouses are concerned.

BACON CURING

Bacon curing, until a little over a hundred years ago, was a domestic a Just as bread was made in the home instead of being produced, as at prese by commercial bakers, so sufficient bacon was cured, in each house or cotta to meet the needs of the family.

In those days a pig and stye were part of every domicile. But at abo the end of the 18th century, commercial bacon curing was started, and enou bacon was cured in one house to satisfy the requirements of the entire villa or hamlet. Gradually this process developed until home bacon curing is n confined to a few outlying farms.

Home curing consisted of rubbing the pork flitches, sides or cuts w salt, then soaking in a brine trough for five or six weeks, and finally smoki in the chimney or laying out to dry. Curing could be carried out only in t cold weather ; thus, in the old days, fattening of pigs was continued un well into the autumn. Slaughtering took place in January and the curing w carried out during the winter months.

The contractor, once commercial bacon curing was founded, soon beg to search for methods by which bacon curing could be an all-the-year-rour

cupation. He built cellars, to obtain a cooler temperature than that prevailing ground-floor rooms affected by the rays of the sun. He then improved on e cellar temperature by using ice.

The advent of mechanical refrigeration had two immediate effects. ommercial bacon curing was rendered so much easier and more continuous at production was increased very considerably. Before mechanical refrigera-on, curing depended on a high percentage of salt for preservation. With echanical refrigeration, curing could be accomplished with a very low per-ntage of salt. Mild cured bacon, as the new curing was known, changed e natural taste from fat to lean bacon. Fat meat is more easily cured than an meat.

The high percentage of salt necessary in curing bacon without refrigeration to prevent the growth of rancidity and mould. The rate of change of glycogen to lactic acid that takes place after slaughter affects the rate of penetration salt into the connective tissues, and the success of the curing depends on hether the rate of penetration is rapid or slow, deep or otherwise.

When an animal is slaughtered, changes in the state of the flesh and nnective tissues take place. So long as the body is well bled, the risk of fection of flesh and tissue by the bacteria in the blood is minimised. Muscles ceive their energy from the supply of starch stored therein. The reason for sting animals before slaughter is to ensure a goodly supply of starch or lycogen. This is renewed from the sugar in the bloodstream. So long as the pply of glycogen is plentiful, muscle structure and connective tissue remains pen and free as elastic. If the supply is limited the tendency is for muscles nd connective tissue to harden and close. Poor starch content sets up a eneral poor condition which in time sets up bone taint, and generally promotes e growth of bacteria.

The fat in dead meats absorbs oxygen, and this absorption tends to produce anges or acidation which in time produces the acid flavour associated with ncidity.

Such chemical changes can be retarded by cooling. Cooling, like salting, nds to "absorb" the water content of the dead meat. The development bacteria requires water and a fairly high temperature. Salting, drying and oling tend to remove the water and thus to retard bacterial development d chemical changes.

Without mechanical refrigeration fat bacon was necessary. The greater e amount of fat, the more the salt which could be absorbed, and the greater e percentage of salt, the longer the bacon could be preserved. With mechanical efrigeration there is less need for heavy salting. Curing can be done to meet e needs of consumption. Fattening of pigs was no longer necessary.

The advent of the mechanical refrigeration brought other changes. Imports pig meat for bacon curing from the Americas were added to by supplies om the Continent. Bacon, already cured, had been shipped from the ontinent, the curing of bacon there being less expensive than in this country.

Curing Methods

Salting is done in three different ways—rubbing salt in, immersing the m in a salt bath, or by injecting a pickle direct into the flesh.

By rubbing dry salt on to the outside surface of the meat, the salt mi with the meat fluids under the skin, and the meat fluids distribute the s concentration throughout the meat. Salt prevents the development of bacter and the meat thus salted can be said to be cured of bacterial growth.

Immersing the meat in a brine bath gives more rapid penetration into a distribution throughout the meat. The wet cure, however, requires mo drying afterwards because the water content of the brine is also absorbed the meat, and unless this is dried out the growth of bacteria will not be arreste

The injection cure is merely an injection of a pickle compound of salt a saltpetre into the fleshy parts of the shoulder, the sides, and the gammo The meats are then stacked in layers with 'tween dunnage, are covered wi salt, and left for five to six weeks.

Of the three curing methods, the tank cure—or wet cure—appears produce the best results, and the more palatable flavour ; it is, also, the lea costly.

The secret of curing is producing that perfect blend of salt and flesh whic results in the most palatable bacon flavour. At the same time, the curing mu be sufficient to preserve the meat and prevent the growth of bacteria. To strong or too hard a cure ensures preservation, but makes the salty flavou too apparent. Too mild a cure limits the preservation and does not produce good bacon flavour, the fresh meat flavour remaining strong.

The wetter the cure the faster the penetration, but the subsequent dryin takes longer. Salt must not be allowed to remain on the surface of the mea after curing is completed, because it attracts moisture, and bacterial growt on the surface would occur. Therefore, after curing, the meat must be washe and, after washing, the drying must be thorough.

The period allowed for curing is dependent on the thickness of the mea Usually the period is a fortnight. The longer the period the harder the cur but mild bacon is becoming more favoured. Drying is done in two ways— hanging or smoking. The purpose of drying is to extract all the moistur from the meat and to make the outside hard and dry, so that moisture canno again penetrate. Drying by hanging is done by hanging the meat on racks i a current of gently moving air. Smoking is carried out by hanging the side in stacks or chimneys over wood fires. The fire must not be hot and the woo must not be fir, deal or pine. Hardwoods as a fuel are best. Usually sawdus is used, this being allowed to smoulder slowly, damp cloths being used t increase the smoke.

A simple smoke chamber is constructed by using a couple of casks with th ends knocked out, the bottom one placed vertically on bricks sufficient in numbe to allow a small fire to be built. The bacon side is hung inside the to barrel.

Another method is to use a coke brazier. Care must be taken that the bacon is exposed above the brazier only when the coke is glowing and sulphur fumes are absent. Brazier drying, however, is hardly smoking. It is usually known as pale drying.

CUTS

The Wiltshire cut represents the maximum portion of the carcase. This is the whole side less the trimmings, head, neck, tail, shanks, etc. This is then cut into the gammon, ham, middle, and fore-end. The top of the middle is the back, and the bottom of the middle is the belly. The fore-end constitutes the shoulders.

The Cumberland cut is the side without the ham, the ham and neck end squared. The backbone and skirt is removed and the breast bone is cut smooth.

The Clean belly is the smooth side after the back has been cut away, and all bones removed.

The Clean back is the remaining portion of the side after the belly, backbone and ribs are removed.

The Clean middle is practically the same as the Cumberland cut except that the cuts are shorter, and the ribs are taken out.

Rolled bacon is simply a boneless side. The side is boned before curing, and hams and shoulders are removed.

A whole carcase head-on, would first of all be split down the centre of the backbone. The head would be severed from the left side. The ham would be removed, the fore-end would be removed just below the first three ribs, and then divided into collar and fore hock. The side would then be cut down the centre and divided into loin and belly. From a 2 cwt. pig (live weight), a dressed side usually results in a weight of between 60 and 70 lb. This would give a gammon ham of 16 lb., a loin of 18 lb., a belly of 10 lb., a collar of 7 lb., and a fore-hock of 10 lb.

The retailer buys his bacon from the wholesaler usually in the form of the above cuts. Whereas in wholesale dealings a side is sold by the cwt., sales of cuts per lb. must be made at different prices. Backs, gammons and middles are higher priced than bellies and fore-ends. The retailer further cuts up his cuts of bacon, to suit the taste and desire of his customers, the thinner part of the flank being sold as steaks and at a lower price than the back.

RECEIVING AT STORE

The receipt of bacon at the cold store necessitates certain precautions. Bacon usually arrives unrefrigerated, and any large intake, therefore, represents

a big load on the refrigerating plant. Handling is rendered difficult also bec of the soggy nature of a bacon bale or the unwieldy proportions of a 6- case.

BALES

Bales arriving either by road or rail transport are usually bales with hes sewn round, and the bale tied with rope. There are seldom any marks on hessian, but attached to each bale is a wooden tally showing the mark, num and weight. Usually, it is necessary for the checker to take these particul and the practice is for one man to read off and shout out the tally indication, " BHA—4,031—195," and while the checker writes it down, the bale is ro off the lorry on to the truck. Usually five bales are a sufficient load for a c store truck. The truck then has a total load of, say, 1,000 lb., and when chamber is reached, three men are necessary to lift the bales from the tr and place them on the stack.

The bale weight then averages 200 lb., but the soggy nature of the ba makes it most awkward to handle.

Bales are sometimes received damaged, torn with dock crane hooks, pilfe (pieces cut off), or open, with the hessian wrappers torn. Such bales sho be specially reported, specially weighed on the scale, and specially stored apart from the main stack, so that they are accessible.

One bale of each mark should be stored separately so that inspecti can be made later. A consignment of say 1,000 bales may have five or mo different packer's marks. Adverse reports on condition or quality m be received and may refer to a special mark, and inspection as to keepi quality of the marks may be necessary during the period the bacon is store.

Checker's notes should show the condition of the bacon on receipt, that "wet" or "very wet," the condition of the hessian, whether clean or dirty, t number of marks in the consignment, the condition of the transport, the numb and details of each bale test-weighed, and the reason for such test-weighin In addition, of course, the usual particulars of consignment must be logge as with all receipts of any class of commodities.

Bacon is either carried in the fore-holds of ships, below the water line, in refrigerated holds held at a chilling temperature. If shipped by ra insulated but not necessarily refrigerated vans are used. The bacon is " green or pale dry cured—not smoked, and on arrival at cold stores is definitely an unrefrigerated state. .

Hams and fore-ends shipped in cases are usually paper wrapped or bor covered. Dependent on the length of time which has elapsed during transpo deterioration is usually beginning when bacon receipts are handled at t cold store. No time should be lost, therefore, in getting the bacon inside t chambers.

STACKING

Stacking is done on 3 in. by 3 in. battens and it is advisable to use 'tween dunnage. Due to the soggy nature of the bales, however, the centre of the bale resting on 'tween dunnage is liable to sag. A better method, therefore, is the criss-cross stow, missing out a bale in each alternate layer as in the accompanying diagram. This allows for through ventilation and maximum air circulation.

A great deal of head room is lost in stowing bacon. The limit of safety is seven bales high, and this calls for strenuous efforts on the part of the stackers.

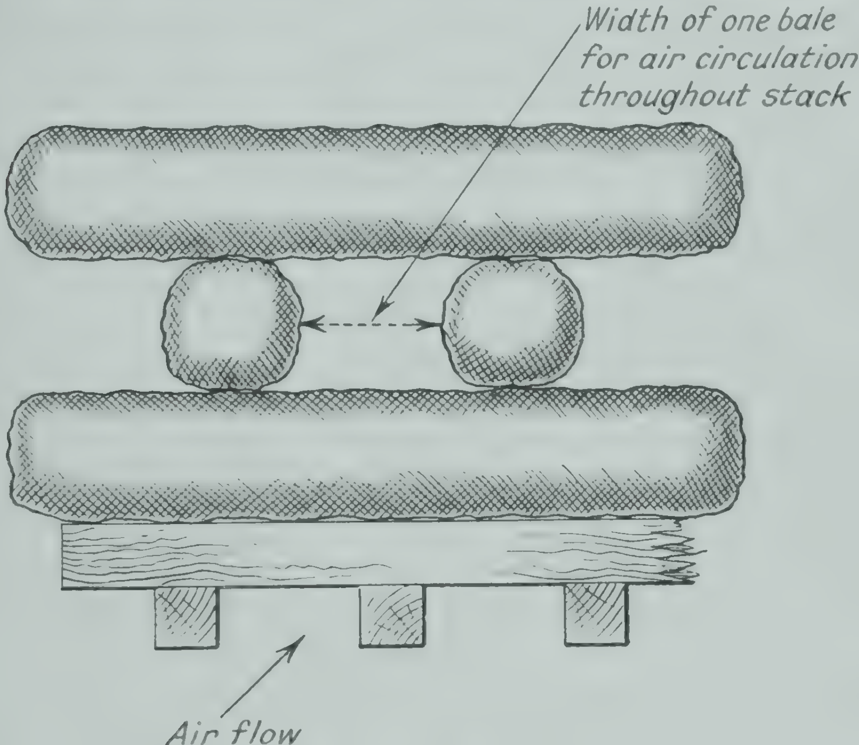


Fig. 23.—Bacon Bale Storage.

Even at seven bales high the bottom bale is liable to be unduly pressed. Five bales high is the average stacking height, and this usually means that only half the capacity of the chambers is being used.

The refrigerating plant will be fully taxed for the first 12 hours after an intake of bacon. It is imperative, however, that the bales should be cooled down rapidly, and that a room temperature of 14° F. be obtained as soon as possible.

It is probable that a brine liquid will be squeezed out of the bales after stowing, especially if the temperature reduction is slow. This should be taken up with sawdust or lime and brushed out as soon as it appears, taking care that it does not come into contact with the bales.

With cased bacon there is little trouble, but the necessity for reducing the temperature quickly is equally important.

Bales of Wiltshire cuts average nine to the ton and cases of 6 cwt. average $3\frac{1}{3}$ to the ton. Cases can be stowed three high in chambers—in the average eight foot high chamber there is head room for four cases, but it requires effort and slows down the handling speed.

Because of the salt in the bacon, its unrefrigerated state on arrival at the store, and the possibility of either a brine liquid or general moistness coming from the bale, bacon should be stored separated from all other commodities. Of the other commodities, in particular, meats and butter should never be stowed in the same chamber with bacon.

Inspection of bacon should be made frequently. If a bale is opened up and the sides are exposed, the condition can be seen at a glance. If deterioration is developing, the underside of the meat will appear to be slimy. By inserting a trier—a steel skewer or a sharp-pointed knife—into the flesh, especially near the bone, and withdrawing it and holding it under the nose, the extent of the cure and the quality can be ascertained. Nose and eyes are usually sufficient to judge the state of bacon, and if deterioration is far advanced then immediate release from cold store is advisable.

Generally speaking, bacon is seldom a long-term cold storage commodity. One to two month periods are usual, and there is sufficient profit margin to the wholesaler to make cold storage cost preferable to a reduction in selling price consequent on the flooding of the market. One month's cold storage cost will work out at less than a farthing per pound, and the incurring of this extra cost is easily justifiable.

HANDLING

The handling of bacon is somewhat difficult. For some reasons, few cold stores in this country are fitted with cranes on the loading bank. The old-time warehouseman preferred to manhandle 2 cwt. bales and 6 cwt. boxes. But a quick-acting electric crane installed on the loading bank can facilitate and speed up the handling. An electric crane fitted with a grab sling can load or unload lorries much more quickly than three or four men can manhandle a similar number of bales or boxes. The type of truck to be used depends on the situation of the chamber. If a ground floor chamber, two-wheeled trucks are the best. If the situation of the chamber is above or below ground floor level then the four-wheeled bogie, carrying five or more bales at one time, is the most suitable. With bacon, every bale label must be read on both incoming and outgoing stock. It is, therefore, impossible to handle bacon quickly, but it is very desirable to handle it more easily.

In stowing bacon, stacking machines are of considerable help. Hand stacking machines are slow, and an electrically operated stacker is preferable. A 10-cwt. stacker will lift a load of bales five at a time to the height of the stack. It is then an easy matter to stow the bales one by one.

[*Courtesy*: *H. C. Slingsby*

Fig. 24.—Stacking Machines.

CHAPTER 10

POULTRY—FISH—MISCELLANEOUS

POULTRY

CONSIDERABLE cold storage space is required for poultry. Both chillroom a storage chamber capacity is required, and intakes can have quite a hi occupancy conversion in cubic feet per ton because of marks and separatio Local home-killed poultry arrives at the store with the body heat retaine and hanging in the chill room will be necessary before stacking in the stora chamber. Imported poultry arrives in a hard frozen condition, and stacki in the storage chamber can be done immediately. Game, such as pheasan partridge, teal, etc., is also stored, but is little in quantity, and the reven derived from it is small.

Poultry, however, is a valuable commodity, from the revenue earning poi of view, and, being a winter commodity, it is all the more desirable in th it requires space when ample space is usually available.

The price of chickens is low in the autumn and winter months. The eg producing season is over, and chickens are killed off. The supply excee the demand, and refrigerated warehousing is desirable until February, whe supplies decrease and prices rise. The difference between the low and hig peak prices of dressed poultry more than covers the cold storage charges.

The consumption of poultry is higher than is usually supposed. Chicke meat is tender, easily digested, and is ideal meat for invalids. As a cold storag commodity it is of relatively high importance.

Poultry is judged according to its quality at the time of packing. There ar various influences governing the classification which must be considered. Th most important is breed. White Leghorns, Wyandottes, Plymouth Rock Rhode Island Reds, Brahmas, Orpingtons, and Cornish, are some of th principal breeds. In quality, uniformity of size, shape, colour, and texture c skin and flesh come first. Any breed of poultry which excels in egg productio differs from the other breeds mainly in stature, activity, and nervousness.

Small active breeds usually possess small muscle but relatively tough tissu and the flesh, when prepared for table, is relatively tough. A well-fleshe compact body with short legs and wings is generally looked for in the dresse poultry class. Large birds have coarse flesh texture. The sluggish, heav breeds usually prove tender. Orpingtons and Minorcas are white skinne Leghorns and Plymouth Rocks have different flavours, but flavours are ofte influenced by feeding and/or by the preparation for the market. Age can b

judged by the thick connective tissue surrounding the muscle fibres, and the coarseness of the flesh. The age of dressed fowls is detected by the hardness and firmness of the keel bone. A young bird has a loose and soft cartilage supporting its keel bone. Dry skin, hairs on the body, scales on the shanks, hardness of the feet, and long toe nails, together with hard and curved spurs, and hardened windpipe are all indications of age. Sex can be judged by the coarseness of the skin, presence of large bones and a large body, and by the greater development of the spur in the male as compared with the female. Capons have small heads and withered combs, narrower and pointed feathers, and undeveloped spurs.

Preparation for Cold Storage

Special feeding before killing, or in preparation for the market, usually lasts for three weeks, and there are two distinct methods, known as milk and corn feeding respectively. Milk feeding is done to a special system for the production of good quality flesh, and consists of feeding a mash made up of cornmeal and buttermilk. The flesh of the milk fed chicken is softer than that of the corn fed, the skin is whiter, and the flavour is preferable. Before killing, especially after three weeks of concentrated fattening feeding, the bird is starved for twenty-four hours. This is to empty the stomach. A properly starved bird bleeds better after killing, and the flavour and keeping quality of the flesh are improved.

It is essential after killing that the carcase is bled properly. Successful bleeding depends entirely upon the killing method. Wringing the neck causes twisted blood vessels, and incomplete bleeding. The correct way to kill any poultry is the two-operation slaughter. The bird is suspended either from shackles or string (the former is the better), the head of the bird being held firmly between the thumb and fingers of the left hand. The correct grasp is between the eye and the ear but no pressure must be used as this will stop the flow of blood. The knife—double-edged, and with the point in line with the handle—should reach in through the mouth, the point being just back of the skull, and if anything, a little to the left. The point is pressed down, drawn slightly forward, and across the base of the skull to the right. The jugular vein is thus severed, cleanly, instantaneously, and when done by an experienced hand, humanely. Blood should immediately flow out of the mouth.

The knife should then be forced through the rear and roof of the skull. It should be twisted as it is pressed in until it reaches the brain.

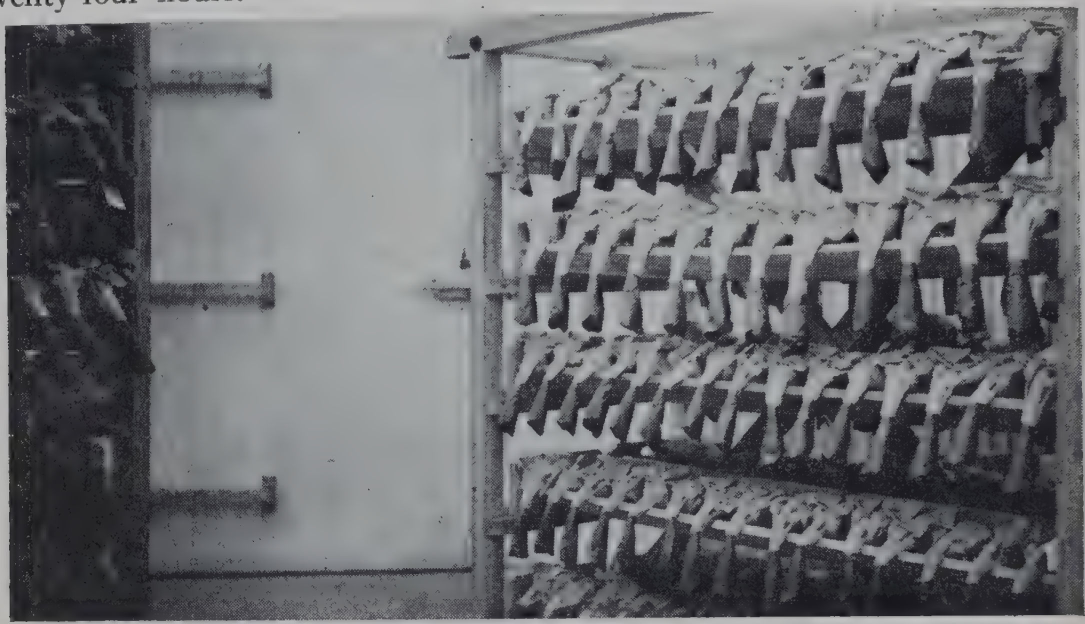
Birds not properly bled may be easily detected. The veins are usually discoloured, particularly on the breast and neck. If green coloured—showing decomposition of the blood, it is possible for ptomaine poisoning to be caused.

Plucking is usually done at the time of killing. There are two distinct methods—dry picking and scald picking. The latter has an advantage in that the picking is rendered much easier after the bird has been dipped into water at a temperature of 200° F. and scalding results in a heightened colour, and

a tendency to have a plump appearance. But the disadvantage which man regard as serious is that scalding causes easy ingress of bacteria and, due t the dissolving of proteins, causes loss of flavour and considerably shortens th keeping quality.

Chilling

Poultry must be chilled, after killing and plucking, in order to remove th animal heat and avoid the entrance into the carcase of bacteria. Chilling, b throwing the carcase into a tank of cold water, is detrimental to the keepin quality, a hot carcase being capable of a great deal of absorption. Birds ar usually put into a chilling room standing at 32 to 35° F. and left there fo twenty-four hours.



[*Courtesy*: "*Modern Refrigeration*"

Fig. 25.—Poultry racked ready for Cold Storage.

If poultry is to be kept for any length of time before putting on the market it will be necessary, after chilling, to place it in a cold storage chamber held at a temperature not higher than 15° F. Usually, poultry is wrapped in greaseproof paper and cased.

Packing

Poultry is usually packed in light wood cases with the boards slightly spaced to allow air entry. The birds are trussed and pressed after chilling and wrapped in greaseproof paper. Seven birds is the usual number in a case and the gross weight averages thirty pounds. A larger pack averages 100 lb. net weight, with usually 24 birds. The stowing of cases is comparatively simple ; the usual floor dunnage is used and 'tween dunnage is advisable. Straw is occasionally used as a packing material, but this should be discouraged.

Admittance of straw into chambers is usually accompanied by vermin, and thus is definitely bad practice. In market stores where intakes are small, but numerous and bulk stowing cannot be undertaken, special arrangements must be made for stowing the cases so that individual marks can be identified quickly. In such circumstances, the only possible method is by racks ; fixed racks all round the walls of the chambers and movable or portable racks in the centre. The cases should be stowed on their sides, with the label ends outward. Thus any case can be identified and extracted immediately, and yet at the same time the maximum use of space is being made.

Inspection

Mould can attack poultry, the white flesh being particularly susceptible, especially if killing has not been accompanied by thorough bleeding. Humidity and lack of ventilation will have the same deleterious effect on poultry as on ordinary meats, and after a month in storage one or two cases should be opened and the wrapping removed so that examination can be made.

In some stores, especially the smaller stores lacking a chilling chamber, freshly killed chickens have been cased and stored direct in a storage chamber. The heat from the chickens has caused mould to develop on other goods stored in the same chamber, and the spore has in turn infected the chickens. The direct freezing of the chickens has been too fierce, and the flesh tissues have been torn, due to the sudden icing of the outside surface.

Given correct conditions, however, chickens will keep for an indefinite period in storage without detriment and showing only a slight shrinkage.

Temperature range, 12 to 15° F.

Miscellaneous

Of game, and other birds, the most common varieties usually seen in cold stores are pheasant and black game. Even these are not in great bulk and as emphasised above, cannot be regarded as everyday cold storage commodities. These notes on commodities are written to be of assistance to cold storage operatives, and are therefore confined to those goods from which revenue can be derived. Occasionally, rare commodities are sent to cold stores, such as turtle, teal, and so on, and the cold storage operative must have an intimate acquaintance with and knowledge of anything he may be asked to store. But such items, simply because there is no great quantity, cannot figure as revenue producing commodities.

Pheasants, ptarmigan, black game, teal, etc., if cold stored at all, are stored neither plucked nor dressed, but just as they are shot. If any packing is used, it is either in baskets or bags.

On the other hand, turkeys, geese, and duck are invariably plucked and cased when sent to the cold store. Traffic in these three items is desultory for the best part of the year, but increases considerably towards the last two months—November and December.

From a storage point of view, turkeys, ducks, and geese can be treated much like poultry. The flesh being somewhat oily and fatty, particularly with geese, requires greater care than poultry, especially if storage is prolonged. Humid conditions should be avoided.

Temperature range, 12 to 15° F.

RABBITS

Rabbits can be quite a lucrative commodity, especially in market or town stores. They are brought in with skins on, in cases, or without wrapping of any kind, tied together in pairs. The latter method is the best, and when hung on a bar inside the chamber, a pair of rabbits is frozen much easier than when jammed together inside a case.

It is sometimes claimed that the shot used for killing rabbits penetrates the body, and causes the spread of bacteria from the intestines to the flesh. The only way to prevent this is to freeze the rabbits as soon as possible.

Chill commodities and storage commodities should be quite separate, and where intakes are of sufficient quantity, the separating of chill from storage is usually a simple and obvious matter. Poultry, game, rabbits and fish—unless imported—usually arrive hot—that is—freshly killed or caught, and still with body heat. Such items should be slowly chilled first before going into a storage temperature. If there is any great quantity, chill room accommodation is made available, and cold storaging principles can be put into effect. If, however, these items are being received in ones and twos, it is difficult to arrange first entry into a chill room, and later, transfer to a storage room.

In most stores handling this traffic, goods are placed direct into a storage room, and the hot goods receive the full effect of the low temperature immediately. Incidentally, the goods in this chamber, already frozen, are affected by the heat of the hot goods brought in.

Fortunately, such traffic is seldom long-term storage. Frequently, the storage period is a matter of days only. Where, however, it is known in advance that goods are brought in for a long storage period, then pre-chilling in a separate chill room should be given.

FISH

Fish is frequently offered for storage when all that is required is chilling or at most a strong chill. In inland districts wholesalers will send their supplies to the local cold store for a few days storage while awaiting retail sale and distribution. It will be more appropriate to deal with this in the section on chill room storage.

The cold storaging of fish is usually limited to the more expensive and larger fish. Salmon, hake, etc., are usually packed in heavy long, narrow cases, and the fish is frozen on receipt at store.

Sharp frozen packeted fish is a separate traffic. This is dealt with in the otes on sharp frozen foods. The normal fish traffic at cold stores can be assified as frozen, wet, and cured.

Many criticisms have been levelled at the fishing industry because of the imitive method and unscientific treatment of the fish during its transport om the time of the catch to its appearance in the retail market. There have een many improvements, but much remains to be done.

When the nets are hauled in, the catch is unloaded into the hold of the awler and broken or crushed ice used for preservation. When the trawler rives in port, the contents of the hold are emptied on to the quayside. Here e fish are packed into boxes, a little ice sprinkled over them, and the fish put ito railway vans or motor lorries en route for the markets.

The narrow width of England is responsible for the slow development of frigerated transport. Fish has arrived at the retail markets fresh enough for le, but not necessarily fresh enough to keep if consumption is desired later. usually happens therefore that fish not sold on the markets and sent to the ld stores are already in an "off" condition. Boxes are wet, and any fish amber is usually anything but pleasant. The moisture and odour are ruinous floors, and cold store rates for fish must be high enough to cover wear and ar, deterioration, and quantity of refrigeration necessary.

Imported frozen fish is an altogether different commodity. The fish is lready frozen, the pack is not wet, and storage is comparatively easy.

Cured fish has one disadvantage—it seldom stands up to long storage, nd mould conditions are soon apparent if any wet fish is brought into the ame chambers. This commodity is, however, more often offered for temporary torage only, in which case a chilling temperature is all that is necessary.

The glazing of fish with oils has been experimented with, and a certain easure of success obtained. The glazing prevents the deteriorating effect of oisture and humid conditions. Other experiments, including that of freezing sh in blocks of ice—are mainly successful, but all have the one disadvantage f increased costs. Fitting out the chambers with metal racks and stowing sh direct on the racks is one successful method, but here again the quantity tored must be sufficient to warrant the expenditure.

Generally speaking, fresh fish is only put into cold storage to await istribution or sales. The storage period is usually extremely short. Imported sh, already frozen, and cold stored while awaiting distribution, is usually fish f a rare or expensive description, the selling price of which is sufficiently igh to permit of cold storage charges being absorbed without noticeable effect.

General fish traffic

Frozen fish can be stored in a chamber with other goods, but when possible, separate chamber is advisable. Zero to 5° is necessary if storage is to be of ong duration, but if not more than a month's storage is visualised, frozen ish can be held fairly satisfactorily at 15°.

Fish to be frozen must be stored in a separate chamber, the floor of w should be of concrete, not of wood. If the chamber is already down to a temperature, and the intake of fish to be frozen is of any great quantity, effect of such an intake will be an immediate rise in temperature. chambers are therefore necessary. One for the storage of fish already fr and held at 0° to 5°, and the other for receipt of fish to be frozen. temperature of the second chamber will fluctuate between 0° and dependent on the rate and quantity of intake.

The fish to be frozen intake will, of course, be transferred from the sec chamber to the first chamber when freezing has been completed, usually t days later.

Unfortunately, with the majority of cold stores the traffic in fish is sel of sufficient quantity to warrant the expense of operating several cham at different temperatures or even of operating one chamber at a tempera sufficiently low to maintain long storage conditions.

Usually, a small quantity of already frozen fish is offered for storage an indefinite and uncertain period. In comparison, a fairly large quan of wet fish is brought to the store, and the storage required is not always cle defined. Occasionally, a light chill is requested for two or three days; at ot times a strong chill is asked for so that storage can be maintained for a w or more, and sometimes definitely hard freezing is demanded.

Cured fish, for example kippers, haddock, and so on, may be brought the store, also for an indefinite storage period. A fish chamber at a mar or inland cold store may be of one hundred tons capacity, pipe cooled, w a temperature fluctuating between 25° and 10° F., and with a flow of traf both in and out, equal, possibly, to fifty per cent. of the total storage capaci

With such a flow of traffic every week conditions would not be ideal. T formation of snow on the pipe coils, and brine and other formations on chamber floor, would be excessive. The temperature fluctuation would great, and fish already frozen and held in the same chamber would be subjec to conditions that would not warrant long storage.

It will thus be seen that three fish chambers are necessary in any c store handling normal fish traffic, the capacity of each chamber being accordi to the peak period of the traffic. The three chambers should be capable maintaining (*a*) for long storage frozen fish: 0° to 5°; (*b*) for wet fish: to 28°; and (*c*) for short storage fish: 10° to 15° F.

With all short storage period traffic, and with a multiplicity of clients su as the fish trade usually involves, there will be considerable separations cases and packages in the chambers.

Methods of stowing, will of necessity be such that every individual c or box can be found quickly. There will thus be considerable loss of spa and chambers will require to be fitted with racks. All cases will requ individual labels to be attached, and stowing must be such that these lab will be visible.

With certain fish there is a greater fat content, and the proneness to rancidity f this fat is noticeable ; this is especially apparent with herring. The storage fe of fish of this type is very short unless the temperature is low and steady. 'emperature fluctuation and high humidity percentage shortens the storage fe considerably.

Even in stores handling only a small quantity of fish, the separate chambers re desirable, and no fish of long storage should be subjected to the fluctuaitons f temperature occasioned by hot intakes. A chamber of one hundred tons apacity should be divided into three separate chambers so that hot intakes re separate from frozen fish, and short-term storage fish separate from long-erm storage fish.

CHAPTER 11

DAIRY COMMODITIES

DAIRY PRODUCE

DAIRY produce provides considerable cold storage revenue. The old saying—"Brown cow, green grass, white milk, yellow butter, etc.," illustrates the range of dairy produce. Refrigeration plays a much greater part in the dairy industry than actual cold storage. Refrigeration is necessary in manufacture, cold storage is required after production and before distribution. Milk and cheese are usually chill stored, but occasionally storage temperature is required for cheese, particularly in cold stores abroad. A new method of freezing milk in blocks is being developed, and such freezing would require low temperature storage afterwards. Generally, however, cold storage at storage or low temperature is required for butter and ice cream, and butter easily heads the list as the principal dairy commodity.

Butter

The manufacture of butter consists of churning the cream until the fat cell walls break and the fat consolidates or until it is solidified. In large-scale manufacture the cream is poured into a glass-lined vat, then to a special pasteurising plant, at high temperature and pressure, thence to a cooling tank and separator, and finally to a holding vat where the necessary moisture and salt are added. Refrigeration is now brought into play, and the butter is frozen hard, usually in 56 lb. blocks.

English butter only occasionally is cold stored. Usually, it passes straight into consumption. There is, however, a large quantity of butter imported from New Zealand, Australia, South Africa, etc., and it is imported butter principally that is received at cold stores.

Butter, as a commodity, is very acceptable in all cold stores. It is easily handled, stows compactly, keeps well, and is usually turned over quickly. The revenue for storage is thus, in comparison with most other products in cold storage, easily earned.

Butter, especially Empire produced, is received in 56 lb. cases, gross weight 63 lb. The cases average 11 inches in width by 13 inches deep and 12 inches long.

Stowed eight cases high, the floor load is thus approximately 504 lb. per square foot, and 70 cubic feet are usually sufficient to store a ton of butter, due allowance being made for gangways and for separations of shipments and marks.

The only dunnage necessary is floor dunnage and while 3 in. × 4 in. battens are recommended, 2 in. × 2 in. are sufficient. Due to the smallness of the butter pack—11 inches, or if the cases are stowed on the broad side, 13 inches—the floor dunnage needs to be spaced fairly closely, that is, two per case. Estimate roughly 140 running feet of dunnage per thousand cubic feet of space or per fourteen tons.

There are various grades of butter common to the trade. Table and manufacturing brands are the two main classifications. Grades must, of course, be kept separate. Table butter will be required for deliveries to retailers, and the other brands and grades for delivery to the blending factories.

[*Courtesy: Wm. Douglas and Sons, Ltd.*

Fig. 26.—Storage of Butter.

Occasionally, when cases of butter in store are opened up for examination, mould spots will be found. This is usually due to the fact that—previous to receiving into store—the butter had been subjected to high temperature and has thawed out. Naturally, if chamber temperatures are allowed to fluctuate considerably, or are maintained at a higher average than 17° F., or the chamber atmosphere has a high humidity content, conditions are conducive to mould development.

Ice Cream Storage

Zero to 5° is the usual temperature for the storage of ice cream. Many cold stores are holding ice cream at 15° but it is recognised that a much lower temperature is necessary. So many cold stores are manufacturing ice cream that it is seldom offered as a storage commodity. Nevertheless it is looked upon as a cold storage commodity. Some cold stores are acting as depots for

ice cream factories in adjacent towns. Ice cream may be supplied and held in storage in bulk, the cold store doing the packaging and distribution as and when required.

It is possible that, in time, ice cream may become a cold storage commodity equal in importance to butter. It is becoming such a universal and popular food that what may once have been thought an exaggerated forecast is rapidly developing into fact.

At the present time, however, ice cream is being stored in various forms of packs, churns, trays, solid blocks, cartoned small blocks, and so on, and storage methods must be adapted to suit the form of pack. Chambers in which a zero degree temperature must be maintained are of necessity heavily piped, and usually this extra piping is in the form of racks or grids on to which the ice cream is stowed.

MISCELLANEOUS STORAGE TEMPERATURE COMMODITIES

There is a much greater range of commodities for chill room storage than for freezing or storage rooms. Everything that is held in storage rooms can be held—for short periods only—in chill rooms. Many commodities stored in chill rooms, however, could not possibly be placed in storage rooms.

By " storage " is meant a temperature of 15° or less. This temperature freezes, and any commodity held must be of such a nature that the tissues or texture would not be ruptured. For example, eggs in shell could not be frozen, fruit would not stand such a low temperature, and anything contained in bottles would be spoilt completely. On the other hand, fruits, etc., have been " sharp " frozen at a much lower temperature than 15°. There is, however, a great difference between slow freezing and sharp freezing. In slow freezing the whole of the commodity is frozen. In sharp freezing only the outside is frozen.

It follows, therefore, that the range of commodities for storage rooms is limited. Nevertheless, it should be explained that in certain countries—dependent entirely on the temperature of the atmosphere—chill room commodities become storage commodities, and *vice versa*. Everything depends on the rapidity with which cold stored goods may pass into consumption, and the amount of defrosting that will take place.

The lower the temperature, the longer the goods will remain perfect *during* the storage, but the shorter the life will be *after* storage.

Yeast, cheese, margarine, lard, etc., are chill room commodities in England or any country where the atmospheric shade temperature is seldom above 80°. Elsewhere, however, they are definitely storage goods.

In this country, the principal storage commodities can be listed as meats, poultry and game, fish, butter, and eggs in bulk without shell. Even the miscellaneous commodities sometimes seen in storage rooms are usually extracted, derived from, or form part of, these main commodities.

Commodities to be held in storage at temperatures well below freezing point can be listed as follows :—

Bacon, beef, butter, cheese (mostly in sub-tropical and tropical countries), cream, eggs in tins, fish, game, hams, hogs, lamb, livers, mutton, pork, poultry, rabbits, salmon, sausages, yeast (in tropical countries).

The freezing point of commodities varies with the water content. The relationship between the specific heat and the latent heat of each commodity, together with the water content, is of interest and if known can be of great use in determining the ideal storage condition and the length of storage period.

In the cold storage data for each commodity given at the end of this volume it will be noted that specific heat and water content values are shown. This data is of considerable importance with chill room commodities. With storage room commodities, however, such data is mainly of importance only in computing the refrigerating load.

The commodities listed above will keep well at steady temperatures not above 15°, and with steady humidity percentage of 80. Shrinkage and store staleness will become noticeable when the storage period is of undue length. From three to six months, however, given ideal conditions, store staleness should not be apparent.

CHAPTER 12

CHILL ROOM STORAGE

PRINCIPAL COMMODITIES

Meats, shell eggs, fruits, and vegetables rank high in order of importance for chill room storage. Other commodities, listed under the heading "Miscellaneous," are many and varied but are comparatively minor commodities in quantity.

General chill room storage calls for wide knowledge of many different foods, and of the considerable variations in the behaviour of different commodities under chill room storage conditions.

Not every cold store handles chill room meats, and chill rooms for meats are usually of special construction. Hops are quite an important commodity, but only certain stores in certain localities cater for them. Hops, strictly speaking, come under the heading of specialised storage. Fur storage is also a specialised cold storage business. Hops and furs—as suspended live matter—cannot, of course be classed in the same category as eggs, cheese, fruits, and vegetables.

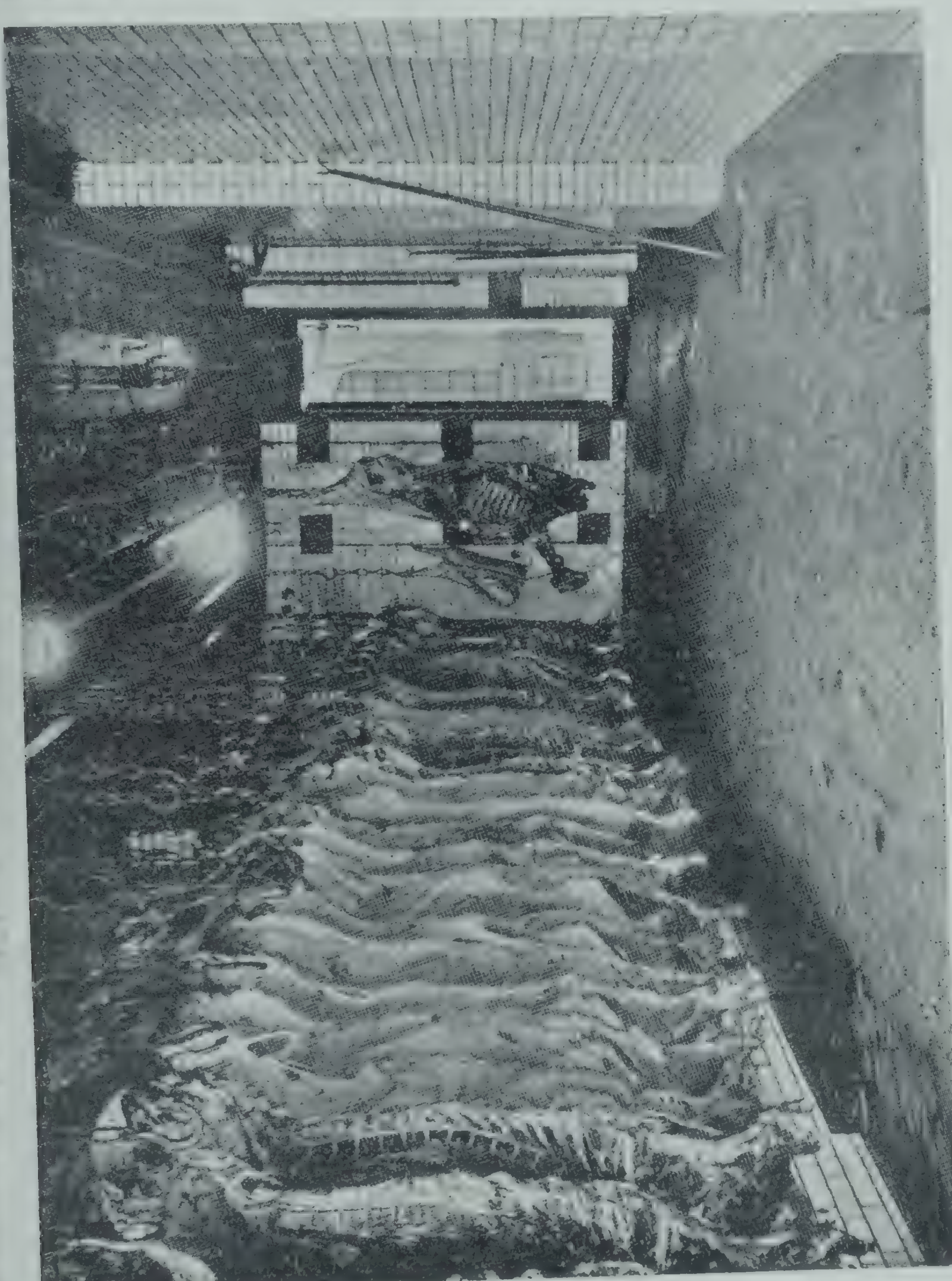
The period of chill room storage is usually short. A storage or freezing temperature arrests and holds development of life, maturity, or decomposition. Chill room temperature retards development. Eggs are possibly the only commodity held in chill storage for more than three months, and for them the usual period is nine months.

Physical and chemical changes occur in all matter. The arresting, retarding, and, in some cases, complete prevention of these changes, is the function of cold storage. Refrigeration and cold storage are fundamentally the same, but they are gradually becoming two separate and distinct sciences. Refrigeration is employed in many different phases of production, but the same products are seldom seem in cold storage warehouses. On the other hand, cold storage warehousing is tending to become more specialised rather than more general ; cold stores are now being specially built for the handling of one particular commodity. Thus we have egg stores, fruit stores, fish stores, ice cream stores, meat stores, hop stores, and fur stores.

Specialisation appears to have developed more in chill room than in lower temperature storage and a good illustration of this is provided by milk.

The preservation and storage of milk, cream and similar dairy products require refrigeration at practically all stages ; for instance, refrigeration is needed during transport, a fact which gives rise to many problems.

A glance at Government statistics will give a slight idea of what is involved. The number of dairy cattle in this country, the millions of gallons of milk produced, the daily consumption of milk per person, the tons of butter, cheese



[Courtesy: Manchester Corporation.

Fig. 27.—Chill Room.

and other dairy produce imported, and also home produced, and the immense extension of the ice cream industry, which the last few years have seen, are not generally realised, sometimes even by those engaged in the industry.

The freezing point of milk is slightly lower than that of water and is dependent upon the fat content. Of milk products, butter has no freezing point, it simply goes harder. Cheese varies with the brand manufactured, but cheddars freeze at 6° to 8°, and gorgonzolas lower still, at around 2° F.

What is termed the cryoscopic method of determining the quality of milk consists simply of determining the freezing point. The lower the freezing point, the higher the fat content. The higher the freezing point, the greater the proof that water has been added.

The freezing of milk and milk products should do them no harm, provided the method and quickness of freezing, and the speed of thawing, are correct. During slow freezing, the constituent parts of milk tend to separate ; the water naturally freezes first, and the casein, sugar, albumen, and fats last. If quickly frozen, the constituent parts have no time to separate, and thawing will reproduce the original state.

Milk production is less in winter than in summer. The food of the cows varies, the amount of grass available varying with the temperature and atmospheric conditions.

Bacteria develop quickly if the milk is allowed to retain the body heat of the cow, and refrigeration is therefore necessary, as soon as it is drawn from the cow, to cool the milk as quickly as possible to as near to freezing point as can be done without actual freezing.

One of the first cooling plants used on the farm itself, consisted of coils submerged in water, cooled by a refrigerating medium. Water, chilled by passing through the coils, was then circulated through other coils, over which the milk, freshly drawn from the cow, was allowed to pass slowly. The milk was caught at the bottom in cans.

The modern method is to have an ordinary insulated chamber, cooled either by direct expansion coils, or more frequently by brine tank and fan. The cans of freshly drawn milk are placed within the chamber, and usually, after a night's storage, the milk is within the desired temperature range. A surface cooler, through which cold brine is circulated, and over which the milk can pass, is usually fitted in addition to the chamber, so that late drawn milk can be cooled quickly before bacterial development can begin.

For a rough calculation, it can be assumed that 500 gall. of milk, in standard cans or churns, will occupy 160 square feet, and that this amount of freshly drawn milk will require the extraction of 150,000 British Thermal Units. Allowing for quick cooling and abnormal losses, due to door opening and repeated loading of chamber, estimate one ton refrigerating plant capacity per 500 gall. of milk handled.

Milk is forwarded from the farms to receiving stations, and often, depending upon locality and distance, passes from first to second receiving or distributing stations.

The forwarding of milk, either by road or rail, may be a simple matter of transporting cans or churns, or the milk may be forwarded in what are known

s floats. These floats are simply tanks, often glass-lined and insulated. In ome countries, where distances are unusually long, the tanks are refrigerated, ometimes by means of ice bunkers, or sometimes in mechanically refrigerated ans.

At the receiving station, further refrigeration is required to prepare the nilk for bottling, before it passes to retail depots for distribution. Depot efrigeration plants consist of large storage chambers, or a series of small hambers, piped or air cooled to give and maintain a chilling temperature. At many milk depots, small chambers, with independent thermostatically ontrolled plants, have been favoured.

Capacity of plant and size of chamber, depends upon quantity of milk andled. The temperature of the milk on arrival is an important factor, and he time available for cooling, before the milk has to be bottled ready for istribution, must be taken into account. It is proved by modern practice hat a fifty ton refrigerating plant will be quite capable of chilling 10,000 gall. f milk daily, given average working conditions, and assuming the requirements f the depot to be usual. Depot requirements are somewhat different from efrigerator requirements on the farm.

Any commercial firm handling milk realises that profits can be wasted inless ample and efficient facilities are in existence for collecting from farms, ransporting to receiving depots, and collecting from depots for distribution. Consequently, depots are provided with cold storage facilities, and the iccommodation of general cold storage warehouses is seldom required. Neverheless, the cold storage space utilised solely for the short period chill storage of milk runs into many thousands of cubic feet.

Beer and Hop Storage

The quantity of beer consumed, in comparison with milk, is not enormous ; ut it is still considerable. For present purposes, the interest of beer lies in ts need for refrigeration both during and after production. How this affects old storage warehousing can be seen in the following brief description of beer roduction.

Only a general description of brewing can be given, for, as in all special nanufactures, there is considerable variation in the methods employed.

The materials used are malt, rice, corn, hops, and yeast.

Malt is barley after controlled steeping, generating, and drying. The quality of the malt and its colour determine the taste and class of beer made. The nalt is either made in the brewery, or bought from the maltsters. Approximately 50 lb. of malt are required per barrel of beer. This amount varies if other cereals such as corn or rice are used. Each brewery manufactures its own special quality of beer, and this quality is conditioned by the quantity of other cereals added to the malt.

The pleasantly bitter taste of beer is obtained by the use of hops. After gathering, the hops are dried, sometimes in a kiln, sometimes by the sun.

They are then pressed into bales of 200 lb. and put in a store room at a chilling temperature—31° F.

Yeast consists of multitudinous minute plants which produce the enzymes needed to convert the sugars in the wort to alcohol and carbon dioxide. Its action is known as fermentation. The wort is the resultant mixture of the other materials after processing.

General cold storage warehouses may be called on for the storage of the manufactured product and for the storage of hops prior to production. Beer, which comes in barrels or, more often, in bottles, requires only a small chill—40° to 45° F. Beyond care in stacking, there is little requiring attention or special arrangements. The storage of hops, however, requires considerably more care and specialised knowledge.

Hops stored in ordinary dry storage warehouses change colour from green to brown ; change their smell, developing a definite cheesy odour ; lose their resin content ; and, after a few months storage, show a marked and increasingly rapid deterioration.

Cold storage retards these resinous and aromatic changes, thereby helping to retain the constituents on which the value of hops depends. What are known as soft and hard resin contents decrease and increase respectively with the length of period in storage.

Hops differ according to locality. Imported hops, which come here from America and Central Europe, generally keep better than domestic. They arrive at the cold stores in bales, and are kept in chambers at 36° to 40° with a 50 per cent. humidity.

Yeast, usually stored in compressed form, consists of innumerable small living cells. Temperature plays a very important part in the keeping qualities, and humidity content must be steady and fairly low, otherwise mould will develop. In chill rooms yeast will keep for five to six weeks. For longer periods a much lower temperature is required. Abroad, yeast is kept at a frozen storage temperature, and packs are made up as small as two ounce packets instead of the usual one pound pack. A very small quantity of yeast is required per sack of flour in any bakery—2 lb. of yeast per 280 lb. of flour.

Margarine, lard, and other fat compounds are stored in 56 lb. cases. Stowing is easy, and stacks are usually compact. Due to the combination of oils which go into their production, high humidity and temperature fluctuations are detrimental. Chilling extends and improves keeping quality.

Cheese usually packed in crates, two cheeses per crate, matures better in chill room storage. Cheddars, gorgonzola, gruyere, parmesan, roquefort, etc., have a protective covering cloth, but a steady temperature of 45° and a relative humidity content of not more than 75 per cent. are also necessary to prevent deterioration and handling.

General.—Eggs and fruits, etc., need sections to themselves, as the most important of chill room commodities. Apart from these anything can be stored in chill rooms, and nothing but good can result, providing that the

eriod of storage is not too long. Long storage periods usually require low mperature.

ir-Cooled Chill Chambers for Fish

Cured fish and fresh water fish are often offered for chill storage, but this s, of course, for very short period storage. On the Continent, where a onsiderable quantity of cured or salt fish—ling—is eaten, air-cooled chill hamber storage is used extensively. The Spanish bacalou, known in England s ling, is a staple commodity, and the tonnage offered for storage is such hat, from a cold storage point of view, it is regarded as a principal commodity.

The fish is brought to the store in hessian covered bales, and stowed like acon. The temperature is maintained at 33°, and the humidity percentage s never allowed to rise above 82 per cent.

The fish being cured with salt, the evaporative rate is important, and the oss in weight and shrinkage percentage is a principal factor. Opening of bales and test weighing is done frequently, and the least sign of yellowness at the gills is indicative of the necessity for early withdrawal from the store. The period of storage for ling varies from three to six weeks ; it can be of much greater length, but the market value depreciates with the acceleration of shrinkage.

CHAPTER 13

SHELL EGGS IN COLD STORAGE

PRODUCTIVE SEASON

THE increase in the production and consumption of eggs is due mainly to refrigeration. Formerly, during the heavy producing season, the supply of eggs was large, but only a limited quantity could be marketed. With the building of cold stores and the development of shell egg storage there grew a new incentive for the farmer to produce supplies inconsistent with the demand. Poultry farming became a paying proposition solely because of the new possibility of conserving supplies from surplus productive seasons to under productive seasons. The surplus productive season extends over four months in the year—March to June.

PREPARING FOR COLD STORAGE

Eggs are one of the most profitable commodities in the cold storage business. The season commences at the beginning of the productive season in the poultry world. Early April will see the first eggs being shipped to the cold store to remain there for several months. The last eggs are usually withdrawn from the chambers by the end of January. The best eggs, naturally, are selected for storage. Extensive candling discovers the imperfect ones which are put aside for immediate sale. The selected eggs are packed in crates with cardboard divisions, "fillers and flats," or with "excelsior" packing. The crates vary in size according to the country, but the "long case" is usually 6 feet long by 2 feet wide, by 6 inches high, and contains 120 doz. eggs.

The crates when stowed in the chambers should be placed flat—not more than eight crates high, and between each crate there should be two 1-in. battens. Between each tier of crates there should be a 2-in. air space, and between the outside tiers next to the chamber walls, a 4-in. air space at least should be allowed. A more vigorous rule ensures walking space right round the chamber walls.

Care should be taken that no crate is in direct contact with the air from the air ducts. If this is unavoidable and the top crates of each tier are dangerously close to the air slides in the ducts—deflecting boards should be fitted. It is also wise to cover such crates with a sheet of brown paper. In many chambers the rule that crates should not be stacked within less than 6 inches of air ducts is strictly enforced. The bottom crates of each tier should rest on 2 in. by 3 in. wood battens. Any possible air pockets in the chamber should be rigorously avoided, and a free circulation of air round each individual crate should be maintained always.

EXAMINATION OF EGGS

Eggs should be examined for weight, average net ounces weight per dozen. ıeils should be examined for cleanliness, soundness. Air cells should be standard depth, and regular. The yolk should be in the centre and only ghtly mobile. The movement should be examined for direction, whether rtical or horizontal—if the former it is an indication of weakness. There ould be no germ development and the white should be clear, free from blood, eat spots, and foreign matter. The average weight should be 24 ounces per ›zen, and the depth of air cell should be approximately $\frac{1}{8}$ in. With the above mind eggs can be graded accordingly.

SHELL EGGS IN COLD STORAGE

There are six important points to remember.

(1) An egg is one of the most absorbent of cold storage articles, and it absorbs odours easily. Therefore onions or oranges, for example, must not be placed anywhere near eggs.
(2) Fluctuating temperatures damage eggs. Loss of weight is controlled by humidity percentage.
(3) Correct air circulation is necessary. Stacks of cases must have floor dunnage. Each case should have 'tween dunnage. Each stack should have passages between tiers and between walls.
(4) Eggs must not be cooled too rapidly.
(5) Eggs must not be thawed too rapidly.
(6) Eggs must not be frozen.

An egg chamber is a chamber for eggs only. Nothing else can be stored n the room ; all other goods must be prohibited. The goods themselves may e odourless, but the cases, cardboard, or whatever form of packing is used ›r them, may be more than sufficient to taint any eggs stored near them. n egg shell breathes, it is porous, and the description " cold storage egg " om an aggrieved partaker of a fusty breakfast egg can apply only to an egg hich has been stored near other commodities with penetrating odours.

It follows that an egg chamber should be cleaned thoroughly before the eason begins. Limewashing is always advisable and it is necessary that the ir ducts, floor, and dunnage should be limewashed in addition to walls and eiling.

Eggs are the most profitable commodity in the cold storage business. The eason begins in March-April, when eggs are brought into the chambers, until October ; so that seven months' storage at least is ensured.

Eggs are shipped in the long case—6 ft. × 3 ft. × 6 ins.—packed in excelsior packing, or in the " petrol case " type which holds thirty dozen eggs and has separate pasteboard divisions known as fillers and flats. They should be graded before casing for size and colour, but should not be washed ; washing makes them dull and the shell lustreless. Candling is always advisable. Eggs

already bad or turning bad are obviously unsuitable for eight months storag and candling is the only safe method of inspecting them. Testing egg ag and conditions by immersion in salt solutions and the observation of abilit to float is neither satisfactory nor practicable where large numbers ar concerned.

Egg cases should be stacked in chambers on 3-in. dunnage, spaced 2 ft. 6 in apart—both dunnage and cases placed so that they are in the path of air flow

A space between stacks and walls should be arranged right around th chamber so that inspection can be made at any time. A 1-in. batten shoul be between each case in each tier, and each tier should have at least 4 in separation.

Any cases directly underneath or in close contact with the slides on th delivery ducts should be covered with brown paper, and deflecting board should be fitted so that the full force of the delivery air is not directly felt b the eggs in the top case.

Temperature and Humidity

There is only one temperature for shell eggs : no lower than 32° and no higher than 33°. Steady temperatures are very necessary. Fluctuations promote mould. Too high a temperature will tend to develop black spots ; too low a temperature will cause shrinkage and empty ends, and may lead to the freezing and bursting of the eggs. This is frequent in egg chambers in inefficient cold stores. It should not be forgotten that a whole egg is 65 per cent. water, and water freezes at 32° F. The white freezes at a slightly higher temperature than the yolk.

The correct humidity percentage for shell eggs has been found in modern practice to be 80 per cent., and this can be kept fairly steady at a temperature of 32·5°. The importance of relative humidity in egg chambers is due to the fact that the water content of eggs evaporates if the humidity of the cooling air is too low. This causes loss of weight, the air chambers of the eggs increase, and the selling value is reduced. On the other hand, if the humidity is too high, conditions are favourable for mould growth.

Fluctuations in humidity increase both mould growth and evaporation. Modern cold store practice has found that at 32° F., a relative humidity steady at 80 per cent., results in an excellent out-turn after nine months' storage.

Control of Humidity and Temperatures

Temperature control is entirely a matter of plant operation and it should not be necessary to stress the fact that steady temperatures can be secured only by staggered running hours of plant. With the vast majority of stores there is a strange belief that a shut down of plant at night between the hours of ten p.m. and six a.m. is not only economical but also ensures steady temperatures. No egg chamber can keep a temperature without serious fluctuations if plant is not operated over a period of eight hours.

As far as economy in running cost and consumption of electricity is concerned, there is little difference between running plant continuously for twelve hours in twenty-four and running it for four periods of three hours each.

It is true that three watches or shifts in twenty-four hours will mean two more engine men on the salary list, but this is offset by (*a*) cheaper rate of power (running plant at night), and, more particularly, (*b*) lesser losses to be made up on out-turn when eggs are withdrawn. (See also p. 156.)

The limit of temperature fluctuation allowable is from 32° to 33° F., and with the average egg chamber, with average insulation losses, a three-hour shut down of plant would be as much as that short range would allow.

Humidity control is governed by the type of cooling apparatus installed. Egg chambers are air cooled and, with the usual indirect cooling system of brine washed air circulating through the rooms, the density of the brine and the quantity of the brine rain are the two important factors. With a high density brine and elimination baffle plates, the brine washed air should maintain perfect conditions.

Throttling down of brine suction, live or unslaked lime in the chambers, ozonizers, and other methods are definite helps towards humidity control, but have certain disadvantages which tend to introduce other troubles.

RECEIVING EGGS INTO STORAGE

Eggs arriving at a cold store usually have been sorted and graded at a packing depot before despatch to store. Nevertheless, a cold store manager should inspect a certain percentage of cases.

Inspection is very often necessary when eggs are being withdrawn from store as well as when entering. For this purpose sorting and candling rooms are necessary. A room 50 ft. × 30 ft. long with several long tables and benches would be suitable. Ample ventilation, apart from windows, should be provided, and when candling of eggs is in process easy and efficient means for blacking out daylight are necessary.

Eggs must be inspected for cleanliness and freshness. They should not be washed, but all stains or any foreign material adhering to shells and liable to create odours must be carefully wiped off. Only fresh eggs, preferably not more than a week old, should be admitted to storage.

Candling must be done carefully. The usual system is to have several lamps fitted to the tables so that several candlers can work at once. Eggs are taken from one full case, candled, and put into an empty case on the other side of the person candling, moving from right to left.

Candling lamps are usually round cans with a hole in the side. The round can need not be larger than a 1 lb. jam or fruit can. The lamp holder is screwed to the table with wires passing through, and the round can is placed over the lamp with the hole facing the candler. Or the wire can pass through the

bottom of the round can with the lamp holder inside. The egg is held i front of the hole so that the light from the electric lamp passes through th egg shell and enables the candler to see the shadow of the yolk and the siz of the air space. After a little practice the person candling can easily recognis the appearance of a fresh egg with yolk in sound condition and the requisit amount of air space.

The transparency of the egg when submitted to the light proves the quality If the egg is twirled between forefinger and thumb each side of the yolk car be examined. It can also be seen whether the yolk is sticking to the shell whether blood spots are present, and whether air spaces are floating.

Defects in eggs with brown shells do not always show clearly if white light is used, and it is recommended that lamp globes should be blued lightly. The best results are obtained through a blue filter, when blood spots are easily visible.

In sorting and candling eggs, the more obvious rejects are as follows :— Cracked eggs, which should be rejected because cracked are not so readily saleable as uncracked eggs. Mould attacks cracked shells first because the crack is a weak spot easily invaded by mould bacteria. Very often, where sorting does not reveal cracks in the shell, they become visible during candling. Candling will also show a defect known as air cracks. Air cracks are membrane ruptures. The shell is intact but the membranes inside are broken. This weakness of membranes offers little defence against mould attacks, and one such egg in a case containing thirty dozen may be sufficient to cause damage to the whole case. Blood spots usually enclosed in membranes show under candling as dark spots attached to the yolk, and are to be found in eggs laid by young hens. The danger in allowing blood spotted eggs to be admitted for storage is seen when it is remembered that blood spots will in time decompose and cause bacterial growth.

A new laid egg, suitable for acceptance for storage, should appear, under candling, clear and transparent. The white should show plainly, while the yolk should show as a vague mass, tending to darkness in the centre.

If the yolk appears red and movable, and the air spaces at the ends are large, then the egg is fairly old. Any dark spots prove mould, or foreign matter which will cause mould growth later on. Any tendency to black discoloration either in spots or, worse still, extending over the yolk, is also sufficient cause for rejection.

Stowing and Stacking

Egg cases are made of light dry boards of 6 in. width nailed so that there is $\frac{3}{8}$ in. space between the edges of each board. A double partition is fitted in the centre of each case so that cases can be cut in half easily and sold retail. Excelsior packing is usual and must be fresh and clean.

Cases are stowed in the path of the air flow on 3 in. $\times$ 4 in. floor battens. Between each case there should be 1 in. battens. Tiers of cases should not

be more than ten high, but this is governed by the height of chamber. Three tiers of cases wide by four tiers long makes a usual stack, and between each stack there should be four inches of space. Each block of four stacks should be isolated by sufficient space to allow a man to walk sideways all round the block.

Free air circulation round and throughout every stack, no possible blockages, no dead air pockets, and every case of eggs stacked to fulfil these requirements, are the main points needing strict observance when stowing cases. Particular attention should be given to the necessity for a narrow passage to be left around the walls of the chamber. It is also advisable that a space should be left near the door so that stacks are not in the direct line of warm air currents from the open doorway.

The long case containing 120 dozen eggs, which is usually of standard dimensions, stacked eight cases high, requires a floor area of approximately eighteen square feet per eight cases or one tier. This gives a load of approximately 200 lb. per sq. ft., which is well within the factor of safety for average floor construction in most cold stores. Estimating therefore an approximate volume of ninety cubic feet per ten cases it will be seen that a cold storage chamber of 15,000 cubic feet has a capacity of approximately 1,500 cases in tiers of eight cases high after making all allowances for space occupied by air ducts, dunnage, gangways, and necessary air clearance space between stacks.

Whatever packing is used in the cases, wood wool, fibre, straw, or excelsior, too much care cannot be taken in ensuring that it is dry and odourless. A broken egg inside a case incites mould growth, and therefore the packing must be careful and ample. There must be a layer of packing on the bottom of the case and a layer of packing between the top eggs and the cover of the case, and at least two inches of packing around the sides and ends.

Eggs must not be packed tightly: this is very important. If air cannot circulate between eggs and packing, the eggs will absorb packing odours and, also, mould will develop.

Freedom from odour is not the only consideration in the choice of suitable packing. Some packings are liable to absorb moisture. If eggs, after storage in a chamber maintained at the correct humidity, show loss of weight, it is likely that their water content has been absorbed by the packing. It has been definitely proved that the hygroscopic nature of some packings enhances the tendency for water to pass from the eggs to the packing. Packing, therefore, should be as moisture proof as possible.

It has already been stressed that absolute constancy in humidity and temperature is necessary for the long storage of eggs. Two per cent. loss in weight at the end of storage should not be exceeded, but, over a period of seven months, the least variation in humidity or temperature will increase this percentage loss considerably.

The commercial value of an egg is determined by the size of its air chamber. Air chambers may denote freshness or loss in weight.

Experiments have been made to overcome evaporation by sealing eggs wit coatings of oil and wax. Closing the pores of egg shells by such sealing method does tend to reduce loss in weight, but, owing to public prejudice, eggs thu treated are not readily saleable as high grade eggs.

Lustreless eggs, thick whites, weak yolks, and loss in weight are the chie changes which take place in eggs during long storage. Storage taste is also common feature of cold storage eggs. To overcome and remove thes customary defects is within the power of all cold stores. Constancy in humidity and temperature maintenance, a perpetual guard and watch against moul growth and development, and the sweetening of circulating air by ozonizing and deodorizing are the principle features of shell egg expert cold storage.

Humidity and temperature control methods vary with the type of plant installed. Modern refrigerating plant design tends to simplify and perfect control to a point so fine that it was undreamt of a generation ago.

Ozonizing has for several years been developed and encouraged and some very good portable ozonizing plants have been placed on the market recently.

Experiments have also been made with the introduction of carbonic acid gas into the chambers which have been fairly successful in diminishing storage taste.

Mould can be introduced into egg chambers by dirty dunnage, dirty egg cases, or dirty packing. Cleanliness is very necessary and the limewashing of air ducts, walls, ceilings and floors immediately prior to receiving eggs into the chambers is the only way to ensure a satisfactory cleaning.

Removing eggs from cold storage incurs risks of sweating. To prevent this many stores have defrosting plants. These gradually raise the temperature by means of heating units, blowing hot air over the cases.

Whether defrosting is really necessary is a moot point, but the methods of distribution really decide the question. If retail sales can be completed within a short time after issuing from store then the necessity for defrosting does not arise.

CHAPTER 14

FRUITS

FRUIT offers an important seasonal source of revenue for the cold storage proprietor.

Apples, bananas, pears, oranges, grapes, and grape fruit are the principal fruits offered for cold storage, and of these, particularly in Britain, apples take first place.

The object of cold storage is, of course, preservation, but perhaps the phrase " delaying of ripening " illustrates the purpose better. Ripening must be delayed if the market cannot take the whole of production.

Fruits are living organisms and cannot withstand long cold storage ; from three to six weeks is the usual limit. The length of the period depends mainly on the age when picked, the atmospheric temperature and the transport conditions to which the fruit has since been subjected. Apples can withstand four months storage period.

METHOD OF COOLING

As with shell eggs, pipe cooled chambers are not suitable. The temperature for fruit storage is obviously a chilling temperature varying from 31° F. to 40°, dependent upon the class of fruit stored. Humidity control, and efficient air circulation are of first importance, and the brine spray air-cooled system has been proved in modern practice to be the most suitable for fruit storage.

Gas storage of fruit, particularly apples, has been experimented with rather extensively.

Creating an artificial atmosphere for storage purposes is not a new idea. Normal air consists of a mixture of gases, in which both oxygen and carbon dioxide play an important part. Controlling the supply of oxygen and carbon dioxide regulates the speed of development in the vast majority of living organisms. Too much carbon dioxide acts as a poison. Fruits and vegetables, when breathing out of sunlight, consume oxygen and give out carbon dioxide. The rates of the loss of oxygen and of the development of carbon dioxide are approximately the same. Experiments have proved that ripening can be retarded providing the atmosphere can be maintained with a constant percentage of carbon dioxide and oxygen. The results of such experiments have shown that the storage life of fruits can be extended where gas storage is used in comparison with the life in ordinary cold air storage.

Storing fruits in an airtight chamber, and regulating the ventilation is, of course, the simplest method of gas storage. It is not proposed here to go

further into the principles of gas storage. Suffice it to say that gas storage of fruit, in conjunction with refrigerated storage, is capable of much greater development.

Citrus fruits, such as oranges or lemons, are difficult to keep in cold storage, and their great disadvantage is the amount of gas they generate which has to be expelled. Lemons and oranges give a chamber a smell that remains for a long time after the fruits have been withdrawn. Limewashing and cleaning of the chamber afterwards has to be repeated frequently to remove all traces of the smell.

The factors affecting the storage of any class of fruits are the maturity of the fruits, the temperature of the cooling air, and the humidity percentage.

The best storage temperature for any fruit has been proved to be as near the freezing point of that fruit as can be maintained without actually freezing it. However, different fruits have different freezing points.

It should be remembered that the criticial temperature for easy mould development averages six to eight degrees above the best storage temperature. Grapes, for example, stored at 33° F., show no signs of mould, but at 37° mould growth will be evident. The loss of moisture is higher at 36° than at 32°.

Humidity control and the actual best relative humidity for various fruits need careful study. High humidity promotes mould, but too little humidity percentage will cause a dryness in the fruit detracting from its commercial value.

Generally speaking, 34° F. and 84 per cent. humidity have been proved to be the best temperature and relative humidity for most classes of fruit. Steadiness and absence from frequent and rapid fluctuations are of course very necessary.

PRINCIPAL FRUITS

Apples

Apples are the easiest of all the fruits offered for cold storage. They are also the most common, and therefore from a revenue point of view, the most deserving of study. Apples have their own peculiar diseases, and these diseases affect the out-turn from cold stores. This, in its turn, affects contracts for apple storage the following year.

Cold storing of apples is rapidly becoming part and parcel of the marketing and distribution of apple crops. As with most food commodities apples are produced during a relatively short season. Cold storage enables surplus crops to be preserved until ready for retailing during out of season months. Even efficient cold storage, however, has not yet been able entirely to prevent browning of the apple tissues ; but year by year, new methods prior to, and during, cold storage have been tried out, and gradually out-turn percentage has been considerably improved.

There are several common apple diseases. The most frequent are brownheart, scald, and internal breakdown. Prevention and cure are largely a matter of temperature and humidity control.

Brownheart is caused by excess of carbon dioxide in the atmosphere to which the apples are exposed. Browning and decay of the flesh are the usual indications of the disease, which can have serious results if it develops.

Brownheart is a disease that causes part of the apple affected to lose water, a cavity is formed, and the living flesh surrounding the affected part absorbs the water, and in turn becomes affected. If the dead part could be cut out the spread of the disease could be arrested.

The cause of the disease is, as stated, too much carbon dioxide. The same thing can be expressed as due to inefficient ventilation. With correctly air-cooled chambers, brown heart should not appear. Unfortunately, the disease very often originates before the apples are safely in cold storage, owing to bad storage conditions during transportation in ships' holds or railway vans.

Apple scald and spotting is a skin disease which eventually affects the flesh tissues, causing rot and decomposition. Green apples are affected more easily than red or yellow apples, their skins being, apparently, less resistant to the browning which takes place during the early stages of scald development. Browning means that the skin is decaying or actually dead : it sets up rotting of the flesh which spreads until all the flesh tissues have broken down.

Susceptibility to scald depends largely upon the variety of apple concerned. Apples picked from young trees show more scald than those from older trees. Immature apples scald more easily than ripe ones. Obviously, this is in keeping with the colour theory. Immature apples are green. Apples picked in a more mature state have lost their greenness, and are either changing to red, or already are red. It has also been proved that the fruit from trees grown in fairly damp ground is more liable to scald than fruit from trees reared in drier earth.

To a certain extent cold storage prevents the appearance of scald in immature fruit. However, it is reasonable to assume that, since refrigeration delays maturity, scald cannot be arrested if it has already attacked the fruit before admittance to storage. Cold storage will simply keep apples green and, therefore, more susceptible. Nevertheless, it has been found that apples when wrapped in tissue wrappers which have been impregnated with an odourless oil of mineral extraction do not develop scald so easily.

This odourless oil is a special oil supplied by one of the leading oil companies. It is produced by a secret blending and is very effective.

From this it has been deduced that the cause of scald is possibly impurities in the skin which are absorbed by the oil vapours arising from the wrappers.

Internal breakdown is browning of the flesh : it is a breakdown of the flesh tissues. Strictly speaking, it is a combination of scald and brownheart, but it differs from these two diseases in one important respect. Scald and brownheart are arrested by cold storage ; internal breakdown, on the other

hand, is usually a direct consequence of cold storage, or, more often than not, begins during the storage period.

Nevertheless, it is not correct to say that cold storage in itself is the cause of internal breakdown. The disease is most often attributable to too low a temperature, to frost injury, or to dead air pockets inside the chambers, and so on.

Further, when internal breakdown has been discovered in apples stored in efficiently maintained chambers where all conditions have been satisfactory, the origin of the breakdown has been reasonably assumed to be due entirely to the fact that the fruit was left too long on the trees before picking.

It is not reliable to generalise about apples, however. What is perfectly correct concerning certain varieties is, in many particulars, wrong with others. Apples from different localities also differ.

Climatic conditions and soils vary with resultant effects on trees and crops. Various other seasonal and local factors will affect the growth of the crops. Some varieties of apples store better if picked at an early stage of maturity. Others show better storage results if picked when more mature. Apples stored from light or heavy crops will show different storage out-turn results. Apples from different trees in the same orchard picked at the same time and given exactly similar storage conditions will give different results and show, very often, entirely different susceptibilities to the usual diseases.

Of the different varieties of apples offered for cold storage the following are frequently met with :—Newton Wonder, Jonathan, Rokewood, Sturmer Pippin, Bramley, Annie Elizabeth, King Pippin, and Pearmain. There are many others ; and because of the many varieties and the widely different causes of diseases, diagnosing in relation to cause is extremely difficult.

Different cold storage conditions are therefore called for by different varieties of apples.

Despite the warning against generalisations, the cold storage manager, it has to be admitted, must generalise when adopting safety rules for apple storage. He may receive twenty different varieties of apples from each of twenty different fruiterers, all demanding reserves in his insulated space.

In general, therefore, it is wise to adopt 34° F. as the best temperature to hold apples of most varieties. The humidity percentage should not be higher than 84 per cent. and fluctuations of both temperature and humidity should be practically negligible, consistent, of course, with the small superficial fluctuations caused by door opening to be met with even in egg chambers.

Cases should be made of thin wood in 6-in. widths nailed to a 1-in. square batten frame, and with $\frac{1}{2}$-in. space between each board width. Apples should be wrapped in oiled wrappers, and loose excelsior or paper packing should also be used to prevent them suffering bruises and injury from shaking or jolting during transport. Apples should be carefully packed in staggered rows, and the cases should be of such dimensions that the bottom layer of apples will not suffer from the weight of layers above.

[*Courtesy: Trafford Park Cold Storage Co., Ltd.*

Fig. 28.—Storage of Apples in a Manchester Cold Store.
Note floor and 'tween dunnage.

Cases are usually made of dimensions sufficient to take fifty pounds of apples. They should be stored in the chambers on ample floor dunnage, and with 1-in. dunnage between each case. Air space should be left between each stack which should be not more than four cases wide by six cases long.

Oranges

Oranges and tangerines develop considerable quantities of gas, and the smell from this class of citrus fruit is extremely penetrating. Apples in storage *clean* a chamber. Oranges *taint* a chamber. The words clean and taint can be better explained by saying that apples act as a deodorizer, but oranges are exactly the opposite. Eggs can be safely stored in a cold storage chamber recently filled with apples. A chamber that has held oranges would have to be well deodorized and limewashed before eggs could be stored in it.

Oranges are liable to mould attack, and are frequently washed in a 2 per cent. borax solution before storing. Blue mould is thereby prevented—it is claimed.

Oranges should be picked in dry weather. Wrappers are a good precaution against mould development and bruising should be avoided as much as possible. Any bruised fruit should not be cased.

Casing should have the same care as with apples and other fruits. Boards should be spaced, and the fruit should not be packed tightly.

The best temperature at which to hold oranges is 34° F., with a relative humidity percentage of 80. The safe storage period varies between two and three months, depending upon the time and condition of the fruit when picked.

Pears

When receiving pears for cold storage it is necessary to have full information about the conditions under which the fruit was picked, and the peculiarities of the variety offered for storage. The usual defect met under storage conditions is blackening, which is a physiological change caused by picking the fruit too long after maturity, and promoted by poor storage conditions.

Scald and internal breakdown are diseases also noted, and are due principally to the same causes as with apples. As also with apples, pears grown in colder localities ripen more quickly than others. Wrapping is necessary, and bruising must be avoided at all costs. The storage period is lengthened if the temperature is maintained as near as is practicable to the freezing point, which, owing to a very high water content, averages 28°. Hence, the storage temperature is best at 35°, but, even with ideal storage conditions, a certain loss in weight is to be expected. Humidity percentage has proved in practice to be best if controlled at between 78 and 80 per cent. Length of storage varies with the variety of fruit, climatic and local conditions at time of picking, conditions prevailing during transportation from orchard to store, and the handling treatment received. In general, however, sixty days is regarded as safe.

As with most fruits, the two main factors affecting the rate of the ripening of pears are temperature and maturity.

What is known as the respiration rate can be slowed down or retarded by lowering the temperature provided maturity is not too far advanced. At 36° F. the rate of respiration at a given stage of maturity is twice as fast as it would be if held at 33° F.

Good results are obtained by pre-cooling—cooling after picking to, say, 40° F. before shipping, and to 35° during shipment. The life in cold storage, at 33°-35° F., can then be expected to last a maximum of six weeks.

If allowed to ripen on the tree, pears lose flavour and juiciness. They should therefore be picked when green, and handling should have the maximum care. On the other hand, pears must not be picked too early. Pears should be wrapped and carefully packed—pre-cooled from 70° to 40°, shipped at 35°, and cold stored at 35° F. Freezing point of pears averages 28° F., so that even lower than 35° can be maintained providing air circulation is not too strong.

Casing should receive consideration similar to that necessary with apples and oranges. Packing, if anything, should have greater care, pears being liable to bruise easily. In stacking cases, dunnage and air spaces between cases, tiers and stacks, are of great importance.

Grapes

Grapes ferment easily and the quantity of gas developed is considerable. They lack the wide range of varieties found in other fruits, and are not grown in such an assortment of climatic and other conditions. The picking conditions are usually very similar from one place to another.

Being small, their liability to bruising and damage during transport is great. Ripening is not rapid, and keeping qualities are good. Diseases are due principally to bruising.

Packing is usually loosely done in barrels of granulated cork, or small bunches are wrapped in white paper parcels and cased, usually twelve at a time, in light open board cases.

The length of storage is generally between one and two months. The temperature is best held at 34° F. with a relative humidity of 75 per cent. Air circulation should not be too rapid for cases and, if the grapes are packed in barrels, the barrels should be left open at the top.

Grapefruit

Grapefruit is a citrus fruit and stands more rough treatment than other fruits. Nevertheless, care is necessary, and bruising should be avoided. It should be picked after ripening has yellowed the skin, but it should not be over ripe. It should be picked, graded and packed with the maximum of expert care, and should be pre-cooled if possible. It should be held in storage at 34° F. and should keep in perfect condition for at least six weeks.

Plums, Peaches, and Cherries

There are many varieties of these three popular fruits. Research on all of them is continuous, and many experiments in development, selection, and growth are constantly being made.

Their diseases are similar in many respects, and analysis of the causes of failures to retard maturity by cold storage has led to the conclusion that the length of storage life depends upon the time of picking, the method of packing, and the manner of transportation. Picking immediately before maturity has been proved to be the best practice. Packing should be done with extreme care, and cases should provide for maximum ventilation. Peaches must be wrapped singly. The storage period seldom exceeds three weeks. The temperature is most satisfactory at 34° F. with humidity controlled at 75 per cent.

Raspberries, Strawberries, and Gooseberries

Raspberries, strawberries, and gooseberries can be cold stored for a minimum period only.

This class of fruit is seldom offered for cold storage. Ripening is rapid and market conditions are such that crops are cleared quickly.

Figs, Dates, Currants, and Sultanas

These keep well in cold storage. Except in very warm climates, they are not frequently offered.

Nuts

Chestnuts require cold storage in tropical countries, but elsewhere are seldom met in chambers. Chestnuts require care. Humidity control is the most important consideration. In cold storage all nuts should be emptied from sacks into baskets.

Melons, Cantaloupes, and Apricots

These are occasionally put into cold storage. Storage period of a month is usual. Longer periods may result in loss in weight. A temperature of 35° F., with humidity percentage of 78, has been found to give the best out-turn.

Bananas

Of all fruits bananas have had the greatest experience of refrigerated treatment. The banana trade has grown enormously. Fleets of steamers have been built and thousands of railway vans have been specially constructed for the conveyance of nothing else but bananas. The retarding of ripening and the hastening of ripening have required both refrigeration and heating facilities.

The fruit is plucked well in advance of maturity but, when once plucked, ripening develops quickly. Holding a temperature of 34°-38° delays ripening. Any lower temperature carries the risk of freezing. Freezing a banana will destroy the fruit, blacken it, and make it inedible.

Bananas are shipped and put into refrigerated chambers either in crates or in bunches wrapped in the huge banana leaves. Shipment of bananas in paper bags is preferred to crating. It is essential that crates and wrappings should be opened so that the cooling air can penetrate. The fruit—in ripening—develops heat and a considerable amount of refrigeration is required to maintain the desired temperature and to retard the ripening sufficiently.

The period of storage and the retardation of ripening depends upon the market. Cases of still further retarding the ripening—when the state of the market calls for drastic steps to be taken—by throwing buckets of water over the fruit, are well known. This does not improve the fruit, of course, and is definitely wrong. Unscrupulous merchants, however, consider it a successful measure, for the fruit appears on the market at the right time and apparently in the right state.

The period of storage in cold stores is short. The fruit has been on board ship in refrigerated chambers from ten to fourteen days already. One to two weeks in cold storage ashore is usually the maximum period.

Whilst most fruits are confined to a short season in each year, the banana grows practically all the year round. The necessity for retarding ripening is therefore not due, as with most fruits, to fluctuations of market prices with seasonal variations. Ripening is delayed mainly because of the length of transport.

The time for picking the fruit depends therefore on the length of the journey to the retail market. Invariably the fruit must undergo a sea voyage as well as rail transit. The fruit is picked when green. Unlike most other fruits, the banana is cut off the tree in bunches—or hands. Vaselining of the stems and leaving long stalks are precautions which practice has found advisable as a means for preventing main stalk rot. Main stalk rot is the principal disease met with in bananas and it can become serious if allowed to develop. Re-cutting and re-vaselining of the stems is a good way to prevent the disease from spreading.

Frequent changing of storage air is very necessary.

Pre-cooling of the bunch of bananas before cutting it into hands is very necessary. The temperature during storage should not be higher than 55° F., and, if in crates, ample dunnage should be used ; if in bunches or hands, ample separations must be made. Thorough air freedom is important, and admittance of fresh cooled air at frequent intervals is vital.

Popular varieties of bananas are described as the Cavendish, the Giant Governor, the Lacatan, the Gros Michel. Experiments have been made in the gas storage of bananas—that is, storing the fruit in chambers with high carbon dioxide and low oxygen content. These have met with a certain degree of success, but gas storage will not supplant refrigerated storage for many reasons.

CHAPTER 15

VEGETABLES

CABBAGE, broccoli, lettuce, onions, potatoes, etc., are the principal vegetable but it would not be correct to say that they are the principal vegetables fro a cold storage point of view. Actually, vegetables cannot be described as cold storage commodity. The price factor is the main reason why vegetabl are seldom cold stored. In this country, vegetables in season are usually chea Out of season, they are unobtainable. If cold stored they would be to expensive to buy.

Abroad, many vegetables are cold stored because the price factor is not s important. In England, only market stores receive vegetables, and then merel for week-end periods. Nevertheless, cold storage of vegetables is not onl possible, but necessary. Adjustment and a more widespread custom of storin vegetables would influence the price factor sufficiently to make it worth while

NEED FOR VEGETABLE COLD STORAGE

Cold storage of vegetables, as with fruits, definitely ensures longer life A great deal of research is still required, and there is ample scope for experimenta work. Research has not gone very far because it has not seemed justified, and the price of vegetables has been low.

Price fluctuations are however considerable, and during every off season the question of the cold storage of vegetables comes up again for debate.

Market stores cold storage lettuce, parsley, broccoli, and celery, etc. The balance of stock unsold on Saturday is put into store and brought out again on Monday or Tuesday. The cost of cold storage is usually less than a penny per pound and this cost is amply covered. Despite this very obvious fact, the cold storage of vegetables has not become as common as it should, and the reason appears to be founded more on conservatism than on anything else.

With correct storage conditions, and with due attention to all other factors, refrigerated warehousing, up to a maximum period of two months, is possible with practically every type of vegetable.

As with fruits, so with vegetables, and it is to be hoped that the cold storage of vegetables will soon be accepted as not only advisable but definitely necessary.

What can cold storage of vegetables accomplish ? The marketing period can be lengthened, the loss sustained through shrinkage, spoilage, and decay can be reduced to a minimum, the price can be stabilised, and stock supply can be assured.

Refrigerated warehousing of vegetables necessitates research, knowledge of, and experience in, the right time to take the vegetables from the ground, the right kind of packing, the correct method of transporting, the correct type of container for storage, the best methods for storage, the right temperature, and the ideal humidity, the amount of air required, the amount of gas generated and given off by the vegetables during storage, the best methods for counteracting this gas, and so on.

The time to take vegetables from the ground is in the hands of the market gardeners and, at present, is the time when the vegetables are ready for immediate consumption. A little before this time would be much more suitable for refrigerated warehousing.

Many different varieties of packing for vegetables have been tried out, crates, cases, barrels, and sacks. The best pack is undoubtedly the string or net bag capable of holding at least 28 lb. Refrigerated vans, both rail and road, have been designed for meats and bananas, but vegetables are still sent as ordinary cargo. Such cargo is, of course, at the mercy of unfeeling and disinterested transport employees, and is thrown about, packed lightly, and crushed with complete disregard for any result beyond getting the job done as easily as possible.

On arrival at the destination, be it a wholesale or retail market or a small greengrocer's shop, the cabbage, cauliflower, lettuce or whatever vegetable it may be, is exposed to the full glare of the sun. The following day, if unsold, a few dog-eared outside leaves are pulled off, to give the vegetable a newer, fresher, appearance, and, possibly, water may be sprinkled over it to improve the saleability.

Any vegetables that are placed in cold storage must either occupy floor space, thus wasting four-fifths of the chamber capacity, or the chamber must be fitted with racks. Vegetables in sacks or net bags cannot be stored or topped. Cases or crates of vegetables can be topped, of course, but ventilation and air circulation is baffled by the wooden containers.

For safe storage of vegetables, the use of racks deep enough to take one layer of net bags only, and made with light battens spaced at least 2 in. apart, is the only advisable method. Racks can be fitted right round the walls and down the centre of the chamber, with small gangways left between them. These gangways can be filled with portable racks which can be removed as unloading proceeds. In this way no insulated space need be wasted.

Air cooled chambers are, of course, the only type it is possible to use. The air should be diffused rather than circulated ; a fast moving, high pressure chilled air can easily blight the vegetables. A gently moving air that is carried along in such a way that it penetrates everywhere in the room is required. The air should be sufficiently dry to prevent mould formation, but sufficiently moist to prevent shrinkage. Temperature and humidity percentage are—as with all cold storage commodities—the most important factors, and the absence of fluctuations in either is eminently desirable.

Admittance of fresh air, or the purification of existing air, is necessary. Vegetables generate gas and various odours which must be eliminated. Usually the simplest and most satisfactory method of elimination and purification is the use of an ozonizer.

An ozonizer is a mechanical and electrical apparatus for utilising chemical means to remove contaminating substances from the air. Ozone may be regarded as a variety of oxygen. Oxygen, as it normally exists, is composed of molecules each consisting of two oxygen atoms. The ozone molecule contains three oxygen atoms. It is manufactured from the oxygen of air by means of a "silent discharge" between high tension electrodes. Ozonized air is a mixture of ozone, oxygen molecules, oxygen atoms, and the other gases always present in air. Ozone will destroy or help to destroy offensive odours, and will also retard development of bacteria or fungus spores. The apparatus is small, portable, and not very expensive. It can be left inside the chamber plugged in to any electrical connection (see p. 60).

PRINCIPAL VEGETABLES

Celery

Celery has a very short life and rots quickly after picking. It is, however, an increasingly important item, and should eventually prove a consistent cold storage product.

It is an autumn and early winter plant, and because it is not subject to the heat of summer, the need for cold storage has not been recognised. Eaten in its raw state and used in cooking for soups and flavourings, there are unmistakable signs that full development of the popularity of celery has not nearly been reached.

Modern practice has shown that despite the very perishable nature of celery it can be cold stored for two months and show a very successful out-turn percentage.

Certain precautions are necessary. Before accepting for storage, damp bunches should be discarded and only those crates in good condition should be accepted.

High temperatures and excessive humidity are ideal conditions for fostering blight. Celery is a moisture loving plant and, like most vegetables and fruits, it gives off heat. Holding celery in a steady temperature of 35° F. with relative humidity of 78 per cent. will retard ripening, stay rot, and keep the plant in excellent condition.

At one time, celery was used purely for flavouring purposes. It is, to-day, however, very largely consumed and is beginning to rank with the lettuce in popularity. It first grew in the marshlands of England but is now extensively cultivated practically everywhere. The edible part of the celery plant is in the stem or stalk of the leaves. When first grown the celery plant does not have a stem, all the plant food being devoted to the enlargement of the leaves.

Afterwards the stems thicken and it is the flavour given off by these stems that has founded the popularity of the plant.

A common feature of celery in cold storage is a deteriorated and slimy condition of the stalks in the centre of the package. When this begins, other stalks in the immediate neighbourhood will also become affected. It is due entirely to lack of ventilation and to an over-ripe condition when received.

Small and loose packs are necessary and free air circulation is vital. Any celery stalks beginning fermentation should be immediately withdrawn. Humidity and temperature should be steady. The freezing point of celery is 29° F., so that if the chamber is held at 35° no harm will result.

Turnips

Before accepting them for storage see that turnips are free from sprouts. They are usually sent to cold storage in sacks. Sacks should be stored on ample dunnage, with the first rows on end ; the second row should lie horizontally on top of the first and be separated from it by 'tween dunnage. The third row, on more dunnage, should have the sacks placed crosswise. It is important to make sure that air can circulate freely between each row of sacks. Turnips shrink considerably so that whilst the volume of air should be ample, the speed should not be considerable.

34° to 36° F. is the desired temperature with a relative humidity of 75 per cent. If turnips are to be cold stored for any period longer than one month, then both temperature and humidity can be reduced after the first fortnight to 33° F. and 70 per cent. respectively.

Only late varieties should be accepted for cold storage. The early types are not suitable. Freedom from sprouts, bruises, damp, or insect decay is necessary. The condition of the sacks in which they are packed should also be examined. Every care should be taken that all dirt has been removed and that both turnips and sacks are thoroughly dry. Turnip tops should not be too long ; they should be cut back to the crown as close as possible ; certainly not more than half an inch of top should be left.

Cool down slowly and when withdrawals are made allow the temperature to rise slowly.

Potatoes

What has been said for turnips also holds good for potatoes with the exception of the temperature quoted : on this subject opinions differ. Many hold that the best temperature is 50° F. Lower temperatures produce a darkening of the tissues. Potatoes are of a starchy composition, and with lowering of temperature the starch converts to sugar. This probably explains why cold storage potatoes have not been found suitable for frying, and why potatoes held at no lower than 50° F. are more acceptable to hotels and restaurants. At 50° F., however, potatoes cannot be stored for long

periods, and if a long storage is intended a lower temperature becomes necessary.

Generally speaking, then, the best temperature is 40°, with a relative humidity of 80 per cent.

Potatoes can be cold stored very successfully, but examination on receipt, and discarding of sprouts, blights, and decays, must be insisted upon. All vegetables, of course, should be selected before storing, but this is particularly important with potatoes.

Selected potatoes, free from dirt and moisture, in crates, baskets, or sacks (preferably net sacks or bags) can be cold stored for three and four months and be released in perfect condition. Circulating gently moving chilled air at 36° F. should keep the chamber temperature at 40°. Use of the ozonizer daily throughout the storage period is a great help.

Onions

Because of their penetrating odour, onions must be stored separately. Spanish large is the best keeping variety. They should be packed in crates, and circulating air should move all round each case. Arrangements must be made for changing the air so that the new air may come into the chamber and the old air, now gas laden, be discharged. This must be done daily. Under these conditions and with a steady temperature of 33-35° F. and humidity of 80 per cent., sprouting can be prevented and storage maintained for three months with perfect safety.

While onions are usually packed in crates, net bags, as with most other vegetables, are preferable containers. They allow better circulation but make storage more difficult. This difficulty is, however, easily surmounted by the use of racks.

Tomatoes

Not many cold stores handle tomatoes, but with a little capital outlay on special equipment, tomatoes can be cold stored very successfully and produce considerable revenue. Tomatoes have a very long off season, and the price of tomatoes produced under glass can be high.

Green tomatoes can be ripened by turning a chilling chamber into a heating chamber. The temperature should be raised to 70° F. and humidity increased as much as possible. Moisture is essential to ripening as well as to make up the shrinkage which otherwise takes place during ripening.

Once ripened, the tomatoes will hold in good condition at a temperature of 35° F. The equipment necessary for ripening consists of a heater, a unit cooler, and humidifying machine. Trays for holding the tomatoes and removable racks are also necessary. When ripening is completed, the tomatoes can either be removed to another chill room, or trays, racks and walls can be thoroughly dried to remove all moisture and possible fungus spore, and the refrigerating cooler brought into operation.

General

Only certain vegetables have been mentioned, but these notes apply to practically every class of vegetable. Summarised, it can be said that greens such as parsley, lettuce, cabbage, cauliflower, etc., may be stored together in the same chamber. Onions, potatoes, and turnips should be stored separately. Each chilling chamber should have its individual cooler and separate ozonizing equipment. Vegetable chilling rooms should be well fitted with racks, and great care should be exercised in stowing. False flooring, or abundant floor dunnage, is very necessary. Selection of vegetables on receipt should be very thorough, and over-ripe goods should never be admitted. Moisture and dirt clinging to goods should be removed and only clean containers used. Inspections of goods should be frequent, at least once weekly, and any deteriorated or decayed vegetables should be immediately withdrawn.

Some useful cold storage data, with a general summary of the particular chill room and freezing room conditions needed for each of several commodities, are given in Chapter 23 and Table 10 (Appendix).

CHAPTER 16

SHARP FROZEN COMMODITIES

Quick or sharp freezing of perishable foodstuffs is an alternative to cold storage, and is rapidly growing in popularity.

Ordinary cold storage must of necessity be for a limited period only, but sharp frozen products will remain fresh for an indefinitely prolonged period. The old objection that sharp frozen foods lose their freshness has been removed with modern sharp freezing and packaging methods.

It would be useless to develop an efficient sharp freezing process if high temperatures were allowed to damage the food afterwards, because of inefficient distributing methods. Consequently, correct sharp freezing, correct packaging, correct storage, and correct distributing methods for retail sales afterwards must all be considered together.

It will be appreciated that in the freezing of foodstuffs, particularly meats, any moisture contained in the innumerable tiny cells which compose the flesh tissues, will form ice crystals. The longer the time taken to complete the freezing, the more likely are neighbouring ice crystals to grow together as one crystal, of which the size is limited only by the firmness and strength of the flesh tissues.

The microscope reveals a distinct difference between the sizes of the ice crystals which slow freezing and sharp freezing separately produce. In slow frozen foods the crystallisation is definitely coarser than in sharp frozen foods. Large crystals tend to disrupt and compress the flesh tissues. Broken and compressed flesh tissues set up store staleness which promotes bad appearance after thawing and renders the food unpalatable.

In practice, it has been shown that slow freezing tends to destroy flavour and render flesh unpalatable, tough and stringy. Quick freezing, on the other hand, tends to add to the flavour, and to tenderize meat.

Some foods have more water content than others, depending principally upon the fat percentage. The greater the water content, the greater the liability to damage during freezing. Such foods as fish, vegetables, and fruit have a high water content in comparison with meat or game, and the advantage of sharp freezing is plainly evident when considering the results obtained with them.

Particularly, it should be remembered that foodstuffs with high water content submitted to slow freezing must be slowly thawed out. Otherwise the flesh tissues will not have time to re-absorb the moisture so that taste and appearance may be restored to something approaching the original state.

But quick frozen foods do not need to be thawed slowly. The ice crystals are so small that quick thawing cannot do any harm to flesh tissues. That quick frozen foods are put straight into the cooking pot is the rule rather than the exception.

The faster the freezing the more fresh and palatable the food after thawing. Due to differences in water content and fat and bone percentages, different foodstuffs require different freezing speeds. The actual amount of heat to be removed is the total of the specific and latent heats of the water content in addition to the specific heat of the rest of the product. For approximate calculations, it can be assumed that the food product consists entirely of water, and that it must be lowered through 70° of temperature. The usual allowance of 143 B.T.U.s per lb. can be taken as the latent heat, and the refrigeration required can be assessed easily and with a fair degree of accuracy.

PRINCIPAL SYSTEMS

Immersion, direct freezing by brine spraying or fog freezing, and indirect freezing by means of contact with cold plates or surfaces are the three main systems used. Other methods are simply variations of any one of these three principal methods.

Direct immersion consists simply of dipping the product to be frozen into a tank of low temperature brine. The low cost of this operation and simplicity of installation, coupled with the efficient heat transfer which immersion provides, makes this system attractive ; but it has disadvantages and has not been universally adopted. Products such as whole fish or canned fruits can be frozen by immersion, which is eminently suitable for them, but packaged foods cannot be immersed because of the damage their cartons would suffer.

However, since whole fish are not suitable for immediate retail distribution, immersion tank installations for fish are now confined mainly to fishing trawlers.

Fog freezing systems consist principally of cabinets, on the top and sides of which are installed pipes fitted with atomizing sprays through which the circulating low temperature brine is sprinkled. Between the sides of the cabinets are trays on which the packaged foods are placed. The high velocity brine is atomized through the spray needles creating a fog which extracts heat from the foods on the trays. The fog, when heat laden, condenses and the water drops into a tank below and passes into the suction side of the circulation pump for re-atomizing.

The " Z " Process, designed by M. T. Zarotschenzeff, uses cabinets with capacities varying upwards from as little as 100 lb. of foodstuffs per hour. To these freezing cabinets storage cabinets are also fitted with a capacity of one ton or more storage space.

Thus one of the cabinet types at present on the market has two sections. the lower forming the freezing chamber, and the upper the storage room, The overall dimensions approximate 14 ft. by 7 ft. by 8 ft. Insulation is not

less than 6 inches thick and temperatures are maintained at minus 5° F. in th freezer, and at zero degrees in the storage chamber.

The freezer is fitted with a continuous belt, usually made of wire mesl This belt is operated on two shafts rotated by a sprocket wheel and chain outsic the freezer. The sprocket wheel and chain are revolved by a slow speed geare motor.

The foodstuffs to be sharp frozen are placed on the chain or mesh bel made of stainless steel. The conveyor belt draws the foodstuffs through th freezer now under pressure by the atomized spray. The speed of travel i slow, and is adjusted according to the product being frozen. Small thi products such as sole or shrimps require eight to ten minutes only, but thicke fish, meats, or fruits require as much as thirty minutes.

Quick freezing infers rapid removal of heat. The advantage of the brin fog system is that the millions of brine drops present, collectively, a very larg cooling surface. Mainly because of this, it has been found in practice tha the temperature difference need not be considerable. "Z" freezing cabinet operate at only 5 degrees below zero very satisfactorily.

The brine fog having absorbed the heat from the product passing slowl through the cabinet gives up this heat to the direct expansion pipes installec below the belt. These pipes are also installed in the secondary storage cabine maintaining the temperature at zero degrees.

These complete continuous quick freezing cabinets are automaticall controlled. One switch starts up the brine pump and sprays, another operates the condenser circulating pump and the compressor motor.

Hand control switches are also fitted, but mercury temperature switches, operated by temperature differences acting on sensitive bulbs in freezer brine tank and storage room, are the main automatic controls, and expansion valves are set to a narrow temperature range. These thermal valves, usually of the solenoid type, operate from minus 5 degrees to zero.

A thermostatic valve consists of trip gear operating an electrical switch which opens or shuts a valve. The electrical switch is a solenoid or magnet, and the trip gear can consist of quadrants and levers. This is actuated either by a movement of expansion or contraction caused by pressure affected by temperature, or by a similar movement of expansion or contraction caused by temperature effect on mercury.

Operation is simplicity itself ; all that is necessary is to feed the conveyor belt passing through the cabinet. After freezing and removal from the conveyor belt at the other end of the cabinet, certain products, such as fish, are dipped in water at 33° to wash off the brine and give a finished glazed appearance. Some cabinets are designed to give a water spray while products are passing through them, thus rendering unnecessary the double handling.

Whilst many products are passed through the cabinet and packaged afterwards, others are packaged first. Ice cream cartons and fruit juices in cartons in half-pint sizes, are quick frozen in half to three quarters of an hour. Chickens

of $2\frac{1}{2}$ lb. take about the same time. Fish fillets are frozen more quickly, but offals such as kidneys, brains, heads, livers and hearts take longer. For goods packaged or wrapped in cellophane, the time taken averages fifty per cent. longer.

Vegetables and fruits have given successful results, but the value of the brine fog system has best been proved by its use for broken eggs. Eggs can now be easily frozen and stored without the expense of a larger plant.

Large plants designed for freezing fish or fruit or both have been installed in many places. The trend of design generally follows the one main principle. A conveyer belt passes through the freezing tunnel, the length and other dimensions of which determine the capacity of the plant. Belts are made to take one, two, three or four tons of products. A plant designed to freeze fish fillets must of necessity be adjacent to a factory where the cleaning, splitting, skinning of fish, and all the other processes which transform whole fresh fish into appetising fillets, are carried out. When the fillets are prepared and packed into special cartons, either waxed or cellophane wrapped or otherwise made moisture proof, they are placed on trays on the slow moving conveyer belts.

The " Z " process designers have estimated the freezing times of products of different thicknesses as follows :—

$\frac{1}{2}$ lb. carton	$\frac{3}{4}$ in. thick	25 minutes
1 lb. ,, ...	1 in. ,, ...	50 ,,
2 lb. ,, ...	1 in. ,, ...	60 ,,
7 lb. ,, ...	$1\frac{3}{4}$ in. ,, ...	100 ,,

Special problems arise from shrinkage, drying out, discoloration, and loss of freshness, after transference from quick freezer to storage chamber. The cartoning and wrapping help considerably in affording solutions to these problems provided that the products have not been subject to faulty freezing.

If the freezing has been accomplished perfectly, then all the goodness and flavour has been sealed in. If the carton is inferior, the goodness and flavour will tend to leak out in storage.

Indirect Freezing

The ice cream freezer illustrates this principle admirably. Most people are acquainted with the ice cream zinc container immersed in a wooden bucket filled with ice and salt.

Variations of this principle are numerous. Packing the product to be frozen in a metal container, and surrounding this container with a freezing mixture such as brine, glycerine, ice and salt, or having a tray of metal containers sub-divided into cells, and totally immersing the tray in a brine tank, or surrounding the products to be frozen with eutectic inserts, are just a few of the many ideas which incorporate the indirect principle.

Freezing by air is hardly quick freezing, but the system is used for packing fruits, especially in bulk.

The advantages and disadvantages of the different systems depend mainl on the correct interpretation of the optimum conditions governing the quic freezing of each particular product.

The range of temperatures is from minus 40° F. to zero degrees. Th reason why some processes favour very low freezing temperatures, and other prefer more moderate temperatures, is that different food products tend, a any given temperature, to form differently sized ice crystals according to thei water content. Storage afterwards, conditions governing thawing, an peculiarities of the product under retail distribution conditions, must be give full consideration ; otherwise the quick freezing will not be worth while.

As in other branches of industry, it is possible that, as time goes on, th pros and cons of the various quick freezing systems will be weighed agains one another, and that many of the methods now in use will disappear. A present, however, large-scale production based on many quick freezing method and principles is being carried on with most of the food products which already command a popular sale. Experiments are being made with new products and the already wide food range is being considerably extended.

Only food products which stand up easily to storage conditions, and ca easily be packaged, were experimented with in the first days of quick freezing Later, food products which occasioned special problems were considered One by one they have increased the range, and now it is possible to buy almost every kind of meat, fish, vegetable and fruit in a packaged, quick frozen conditio ready for immediate thawing and cooking.

DISTRIBUTION

There cannot be any great development of quick frozen foods no matter how successful and efficient any quick freezing system may be unless methods of distribution are in keeping.

The aim behind quick freezing is to provide a more palatable, more easily prepared, and a much less expensive product for the table. Unless this is achieved, quick freezing fails.

It therefore follows that correct storage in both wholesale and retail stores is of great importance, and that thawing should be understood by every housewife.

Under ordinary storage conditions slow frozen foods are still liable to damage. Two of the changes which take place are often referred to by the terms desiccation and oxidation. Cold store odour is another name for them.

Owing to door opening, the air in any cold chamber becomes at times humid. Condensation caused by hot air from the doorway meeting the cold air of the chamber is carried in the air currents of the room and the moisture thus introduced settles on the goods stacked in the chamber.

In time there is also a more or less continuous passage of moisture from the product to the surrounding air which causes shrinkage, shrivels the flesh, and dries the appearance ; when thawed, the palatable flavour will have disappeared.

What is known as enzymic action is a cause of considerable deterioration which increases with any increase in temperature and addition to the air in the storage chamber. The more oily or fatty the food product, the greater the tendency to rancidity and blackening of flesh and skin.

Storage temperature of quick frozen products should not be higher than zero to 5° F. and fluctuations should be avoided. The same guard against temperature fluctuations should be preserved when the products leave the store for retail distribution. Considerable distances may have to be travelled on road, rail, or sea, or possibly all three, and the container in which the food products are packed will be subjected to various temperatures and humidities.

It follows, therefore, that the packages in which the food product is contained and the container in which the packages are placed for transport, must be of special construction so that, no matter what climatic conditions may exist outside, the inside of the container shall preserve ideal storage conditions.

Even the most efficient and successful quick freezing methods will prove useless if thawing or semi-thawing is allowed before the food product reaches the consumer.

Various methods to prevent this have been tried but the most successful to date is transport inside the fibre board container.

The fibre boards are corrugated, and a container made up of four liners with pads will represent approximately one inch thickness of good insulating material practically equal to cork. It has the additional advantage of being exceptionally strong with comparatively little weight. Weight, of course, is an important item when considering freight costs.

Fibre board containers are made in various sizes but there are two sizes mainly in demand, one to take fifty 1 lb. packages, and the other to take twenty-five.

It will be appreciated that these containers keep temperatures better when filled, and that packing them half-full or three-quarters full is not economical. From trials made over a long period, it has been proved that after three days' travelling under arduous climatic conditions, the contents of a fibre board container are found to be still perfectly hard frozen.

Tests made with these fibre board containers were carried out in the laboratory, in cars on coast to coast journeys in the United States, and in railway vans on different railways operating in sub-tropical and tropical regions. The tests were conducted throughout a twelve months' period. Data was collected on the condition of goods packed in these containers at the end of the journey, and at different stages of the journey. It was proved that hard frozen goods packed in a fibre board container would remain in that condition, travelling through the tropics, for a maximum period of three days.

Using dry ice or solid carbonic acid in the containers ensures more perfect conditions, but the cost of dry ice together with the cost of the container plus the cost of freight, may make the resultant price of the food product prohibitive.

The choice of a package for the food product itself has for a variety of reasons been fixed on the rectangular cardboard box. The cardboard must be moisture proof and for selling reasons the lid or cover should have a window. The shape is important because of packing by automatic machinery, and because of utilising the smallest space in the container.

In the ordinary retail shop, a storage cabinet is necessary because the purchaser must be given her food package in a perfectly good frozen condition. The old-fashioned shop storage cabinet with a mechanically controlled temperature range of 30-40° F. is unsuitable for quick frozen products.

Storage cabinets for quick frozen foods must maintain a zero temperature. Many cabinets are also fitted with sufficient reserve refrigeration—in case of a mechanical breakdown—for prevention of temperature rise for twenty to thirty hours.

Because of the lower temperature range the quick frozen foods storage cabinet differs from the old type cabinet in that the insulation is heavier, the refrigerating plant is greater, the allowance for heat losses through door opening and window leakages must of necessity be more. Special precautions against frosting over of windows because of lower temperatures must be taken. These cabinets are more expensive than the old type retail refrigerated counter. Retailers recuperate their capital expenditure in due course, the time taken being dependent on their turnover.

In order to help retailers promote sales those engaged in this new industry of quick frozen foods are extending the variety of products. Fish, meats, poultry, vegetables, fruit, are now retailed in half-pound and pound packages.

There is one point about quick frozen foods which never fails to appeal to the housewife. The saving of waste cannot be too greatly stressed. Every ounce of a quick-frozen packaged food is edible. There is nothing thrown away. The full content of the package goes to the table and usually even the most fastidious eater will leave nothing on the plate. Full value for money can therefore always be claimed.

CHAPTER 17

PIPE COOLED AND AIR COOLED CHAMBERS

CHOICE OF COOLING SYSTEM

Air cooling and pipe cooling each have their advantages and disadvantages, and general opinion is divided as to which is the better. Of pipe cooled rooms we must consider both direct and indirect systems. Each system necessitates the presence in the chambers of pipe coils suspended from the ceilings. The direct system has ammonia or other gas refrigerant circulating through the pipes. The indirect system has brine, already cooled by ammonia or other refrigerant, circulating as a medium.

The direct system, or direct expansion, D.E. piped, is definitely the more efficient. The extraction of heat is much more rapid. On the other hand there is the ever-present possibility of the escape of refrigerant from defective pipes with consequent damage to goods stored inside the chamber. Pipes for direct expansion must therefore be of superior construction, and all joints, welds, and flanges absolutely gas tight.

The indirect system enjoys a freedom from gas escapes and consequent damage to goods. Regulation and control of the circulation of brine is much easier. Temperatures are a great deal more uniform, the brine remaining in the pipes maintaining the temperature long after circulation has stopped.

In air-cooled rooms the air is cooled by coolers outside the chambers and then circulated through the rooms by means of ducts.

In weighing the advantages and disadvantages of each system, we must consider the cost of installation, the refrigerating effect, and the cost of obtaining that effect. We must take count of the space inside the chamber occupied by pipe coils as against the space occupied by air ducts, and of the condition of goods after long storage in a pipe chamber in comparison with goods stored in an air-cooled room. In addition, the work entailed in keeping pipe coils clear of snow as against the work necessary to maintain an air battery in efficient condition, must be judged and assessed.

It will be found that the advantages and disadvantages of the two systems balance fairly evenly ; the cost of installation and maintenance, also, are not markedly different. Consequently, no particular preference has been shown for either. Geographical and other conditions, together with the class of business in which the cold store is engaged, are the factors which chiefly influence the choice of cooling system.

Pipe manufacture and pipe coil installation are now of such excellence that the old possibilities of gas escapes have been very nearly eradicated. The work

entailed in snowing down pipe coils has also been minimised by the use of hot gas and other defrosting methods. Air coolers have been so improved that installation and maintenance cost have been reduced considerably, while efficiency has been very much increased.

The trend for the future appears to be for ever lower temperatures. This, together with the desire for more rapid freezing methods, suggests the direction in which cooling systems will develop. It is most probable that direct expansion grids and coils will be adopted to an increasing extent as the storage temperature to be maintained moves ever downward.

DIRECT EXPANSION PIPE COILS

Given adequate insulation the length of piping required to maintain a storage temperature in chambers of less than 10,000 cubic feet capacity is one running foot of 2-in. ammonia pipe for every ten cubic feet of insulated space. But insulation remains neither perfect nor adequate ; it deteriorates with each succeeding year. Any piping allowance must, therefore, make provision for decreasing efficiency of insulation.

Two-inch diameter solid drawn piping is customarily used for chamber coils. Smaller diameter piping necessitates, of course, the use of a greater length to provide the required area of cooling surface.

Although it is proposed in these notes not to delve into the technicalities of refrigeration, but to provide information useful solely for the cold store operative rather than for the engineer, a knowledge of the steps necessary to calculate the refrigeration required for various sized chambers should be possessed by any cold store operative aspiring to an executive position.

Simple calculations may be based on the rule that in 24 hours one square foot of cooling surface will extract 50 B.T.U.s of heat for every degree difference between the temperature of the circulating refrigerating medium, and the temperature desired in the chamber.

A B.T.U. or British Thermal Unit, is the amount of heat required to produce an increase of one degree Fahrenheit in the temperature of a pound of water at normal pressure, or one 180th part of the heat necessary to raise one pound of water from 32° to 212° F.

Refrigerating Load on Storage Chamber

The refrigerating load is equal to the refrigeration required to overcome the sources of heat in a storage chamber. Given an empty chamber with a certain known temperature, the refrigerating load is the capacity of the chamber multiplied by the difference between the known temperature and the desired temperature. Once the desired temperature has been obtained, the refrigerating load is simply the refrigerating effect necessary to overcome the insulation losses, the heat given off by men and by lights during work in the chambers, the heat admitted from outside air when bringing in goods, and the heat given

up, in the chamber, by the goods. If goods are brought in unfrozen, there is the latent heat of the goods in addition to the sensible heat.

All these heat losses can be considerable. Accurate calculation is difficult. The heat given up by the goods brought in for storage can be calculated to a certain extent, but the heat losses in other ways can only be assumed. These assumptions are taken, or are based on figures from actual performance in various cold stores. Checking assumptions with actual calculations made as carefully as possible, it has been found that in practice it is necessary to add approximately 30 per cent. to calculated refrigerating loads in order to allow for a safe mean between maximum and minimum requirements.

In actual practice it has been shown that the average sized storage chamber in the usual cold storage warehouse, handling the average mixed storage business, will have a traffic or movement daily of roughly $\frac{1}{30}$ of its capacity. Based on this assumption the refrigerating load in a chamber of 20,000 cubic feet capacity (*i.e.* 200 tons) averages out at about seven tons per day. That is, seven times 313,000 B.T.U.s must be exhausted.

Thus, a cold store of 300,000 cubic feet having, say, twelve chambers each of approximately 20,000 cubic feet, and ten chilling chambers of 6000 cubic feet, would need a refrigerating plant of 84 tons capacity.

Seven tons per day per chamber would be the maximum refrigerating load, and the chambers would be so piped that a refrigerating effect equal to seven tons could be applied.

The ratio of the length of piping to the cubic capacity of a chamber necessary to give a refrigerating effect of seven tons per day is approximately one to eight. That is, one running foot of 2-in. direct expansion piping to every eight cubic feet of insulated space.

The diagram of pipe ratios given is useful for estimating the length of piping required for any sized chamber for any desired temperature. As has already been pointed out, the cooling surface required depends on adequate insulation and other considerations, not least of which are the length of storage and the frequency of intakes. We have averaged out the refrigerating load on chambers generally as seven tons per day, but the same chambers *may* require considerably more refrigerating effect if engaged in a particular class of refrigerated warehousing where goods are brought in, possibly hourly. The diagram, however, does not provide for such extreme circumstances, and applies only to chambers in stores engaged on the average refrigerated warehousing business.

The diagram is based on coils of 2 in. diameter. If smaller piping is used, for example, $1\frac{1}{2}$ in., use only three quarters of the ratio.

D.E. Pipes and Connections

In the older cold stores, all pipe joints in direct expansion were flanges. The impossibility of making any other type of joint gas-tight prohibited the use of anything else but flanges. This added to the cost of installation, and

even the flanges leaked occasionally. Nowadays, however, flanges can be dispensed with except where valves must be fitted ; elsewhere all joints can be welded.

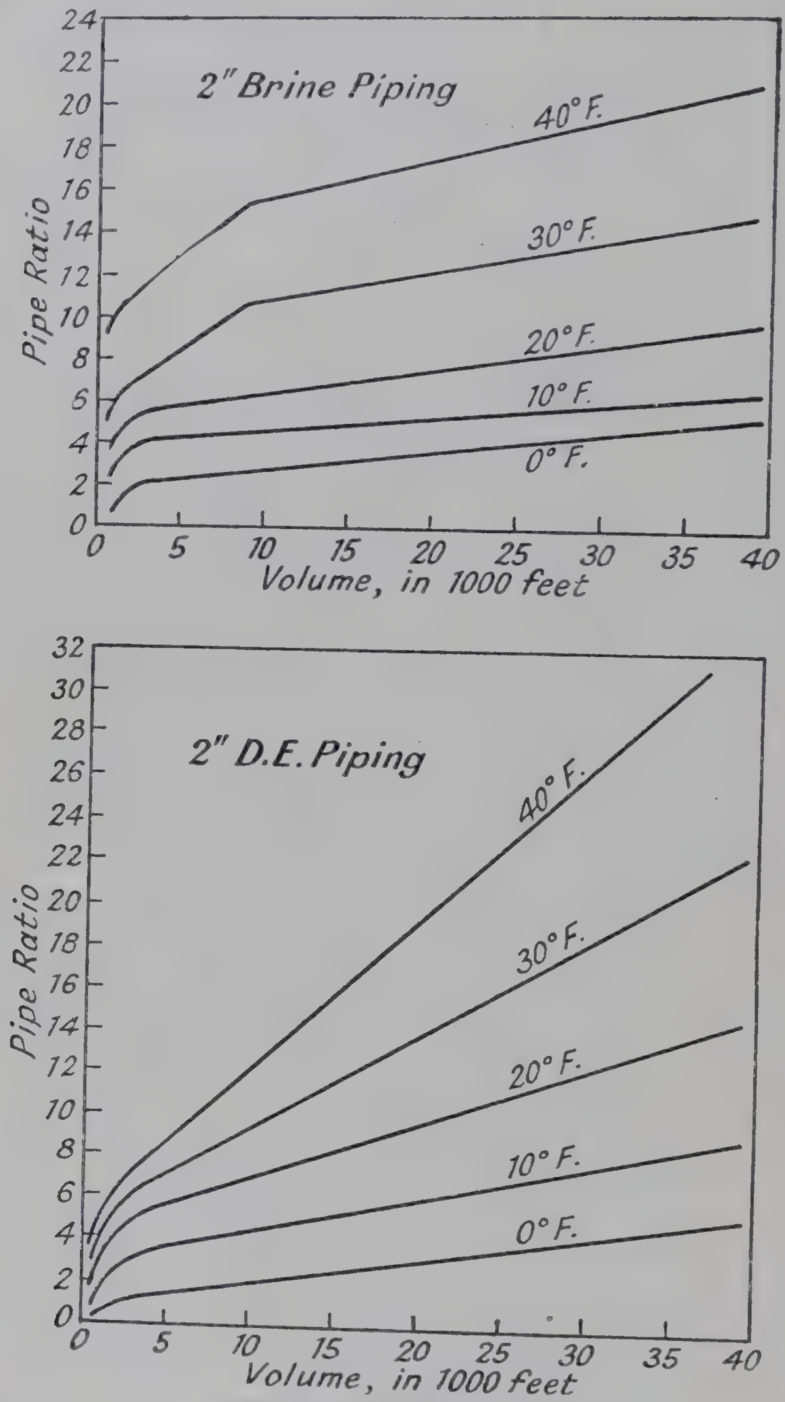


Fig. 29.—Pipe Ratios.

There is a limit to the length of a coil. If the cooling surface for a chamber must be, for example, 3,000 feet of 2-in. pipe, this long length cannot be made in one coil. The longer the coil, the greater the friction. The velocity of

the gas, and its temperature, will also be affected. Piping will expand and contract according to the outside temperature and the length of the pipe and the temperature difference between circulating refrigerating medium inside the pipe and room temperature outside the pipe. At 15° F. 100 feet of 2-in. pipe will vary in length 0.38 inches. The velocity of ammonia through expansion coils is mostly satisfactory at approximately 1,000 feet per minute. Usually, it is the practice to make D.E. piping in coils of 10 to 12 pipes, each pipe being of two 20-foot lengths, a total length of coil from 400 to 500 feet.

Each coil will be connected to a common suction pipe, and a common liquid feed. One point that is of especial importance is the method of passing suction and liquid pipes through insulated walls. If pipes are passed through the insulation without making a separate box the condensation that takes place within the insulation will, in time, corrode the pipes, and pitting will commence, resulting in holes. All pipes passing through insulation should be boxed in and thus separated from the main insulation. The separating box must, of course, also be insulated and sealed, otherwise the pipes will simply act as heat conductors.

With D.E. piping, valves are of special construction and are usually doubled, so that repairs can be carried out without emptying the whole system. Expansion valve spindles require constant maintenance.

Suction and expansion pipes or liquid feeds will be of a diameter in proportion to the amount of gas being drawn from, and liquid ammonia being fed into the coils. Usually, each nest of coils in the chamber is provided with a suction and liquid valve for isolation purposes. Outside the chamber, an expansion header is installed. This is simply a liquid feed pipe from condenser receiver, possibly of $\frac{3}{4}$-in diameter, joined to the centre of a short length of $1\frac{1}{2}$-in. piping. From this $1\frac{1}{2}$-in. piping a number of $\frac{1}{2}$-in. diameter branches terminate in double $\frac{1}{2}$-in. expansion valves, one for each nest of coils in the chamber. From these valves pass the $\frac{1}{2}$-in. liquid feeds.

Direct expansion pipe coils are suspended from, but not too close to, the ceiling : room must be allowed for snow formation. Where, as is sometimes necessary, pipe coils are installed along the walls, they should be at least 3 in. away from the walls. Coils should be installed along the length of the room, not across the width.

INDIRECT COOLING BY BRINE PIPES

Brine pipes are installed in chambers in the same way as direct expansion pipes. Naturally, a lighter pipe is used, joints are more simple to make, sockets are quite sufficient, flanges being unnecessary. Valves are the ordinary stop valve type; inlet and outlet leads to and from the main header are installed so that any particular nest can be isolated at any time. Approximately the same length of piping as with direct expansion piping forms one nest.

With brine pipes the brine, before being circulated, is cooled in various forms of coolers. Usually, the enclosed shell and brine type of brine cooler is preferred. With direct expansion, the relationship between the temperature of the ammonia gas inside the pipes and the temperature of the chamber is all important. With brine pipes, the relationship between the temperature of the ammonia gas and of the brine in the cooler must be considered, together with the relationship between the temperature of the brine circulating in the pipes and the temperature of the chamber.

Because of these two relationships the length of brine piping required in a chamber is theoretically somewhat greater than that required for direct expansion piping. On the other hand the body of brine contained in the coils

[*Courtesy: T. A. Raymond*

Fig. 30.—Pipe-Cooled Chamber.

continues to produce a refrigerating effect even after the refrigerating plant has been shut down. Direct expansion piping will obtain a desired temperature more quickly, but brine piping will retain a desired temperature much longer. Therefore, piping surface whether for brine or for ammonia can be based on the same pipe ratio.

SNOWING DOWN OF PIPE COILS

Snowing down, that is, cleaning the pipes of too thick and too heavy an accumulation of snow, is one of the worst features of cold storage work. It is very necessary work, for snow acts as an insulant and prevents the pipes from absorbing heat from the chamber air. The rate of snow formation varies with the amount of door opening and the class and condition of goods admitted to the chambers. Wet clothes and wet feet are the result of a day's snowing

down by the old method of pipe scraping. The modern cold storage warehouseman is picturesque in the eloquence of his objections to the job: snowing down is his pet aversion. However, it must be done, and in order to find a solution to this increasingly difficult problem, many coils are fitted with hot gas and hot brine arrangements. By circulating hot gas or brine through the coils, the snow loosens and drops off in the form of flakes.

Non-freezing oils applied to chamber door gaskets will tend to prevent icing-up. This same principle applied to cooling pipes considerably helps towards a solution of de-frosting troubles and problems. Non-freezing pastes are supplied in small drums weighing approximately twenty-eight lb. This paste spread liberally over the pipe surface prevents snow from forming and does not act as an insulant. It is claimed that one lb. will cover twenty-five feet of 2-in. pipe surface.

AIR COOLED ROOMS

There are four systems of air cooling, but all are variations of one principle. Cooled air is conveyed to the chamber by means of delivery ducts and circulated round the room. The air on its return from the chamber passes through a suction duct back to the battery where it is re-cooled. The four systems differ in their air cooling batteries, which are of the types listed below:—

(*a*) Old type dry surface battery.
(*b*) New type dry surface battery.
(*c*) Old type wet battery.
(*d*) New type wet battery.

(*a*) *Old Type Dry Surface Battery.*—Brine or ammonia pipes are built in stacks ten to twelve pipes high, and connected by return bends in the same way as atmospheric condensers. These stacks are built over a shallow tank, either inside the chamber itself or in insulated housing adjacent to the chamber. Suction and delivery ducting connect each end of the housing around the battery. An electrically driven fan, preferably direct connected, blows or draws air over the pipes, and circulates it through the ducting around the chambers.

Such batteries are quite efficient, but the stacks of pipes accumulate heavy snow formations which must be continually cleared. The pipes are scraped, the snow falling into the underlying tank. The snow can be gathered to one end of the tank, and shovelled out of the battery housing.

(*b*) *New Type Dry Surface Battery.*—This is similar to the old type, the difference being that it makes use of radial fins sweated on to the outside of the pipes; an equivalent cooling surface area is thus obtained in a much smaller space. The snow formation is very much thinner, is more easily controlled, and very easily cleared.

(*c*) *Old Type Wet Battery.*—There are five principal parts of the old type wet battery: the tank, the ammonia coils, the baffle or eliminator plates, the pump, and the fan.

The tank is usually about eighteen feet long. Sometimes the ammonia coils are built into the tank, other designs have the coils built in stacks above the tank.

A distributor trough above the coils allows the brine to fall down into the tank in the form of rain. The tank is shallow and the pump handles a quantity of brine just sufficient to maintain the necessary difference between the temperatures of the delivery and of the suction air.

[*Courtesy*: "*Modern Refrigeration*"

Fig. 31.—Air-Cooled Storage Chamber.

The fan forces the air over the coils, and through the brine rain. The air is thus not only cooled but washed ; the water vapour collected is extracted by later contact with the baffle or eliminator plates. Thus, only dry, washed cold air enters the chambers.

(*d*) *Shell and Tube Brine Cooler.*—This is the most efficient type of brine cooler for an air battery. A horizontal or vertical shell cylinder with internal tubes through which the brine circulates. The brine is cooled by the ammonia surrounding the tubes. The brine after passing through the cooler passes to the top of the distributing trough and drops over the baffle plates in the form

of rain through which the circulating air is blown or drawn to or from the chambers.

It is claimed for this type of cooler that efficiency is high, that brine density is more easily controlled, and that heat losses are more easily overcome.

Brine Density

The brine used for coolers consists of a solution of calcium chloride in water. Calcium chloride is a waste product from salt works. It is also a by-product from the chemical manufacture of chlorates, carbonic acid, soda, and so on. It can be obtained in 5 cwt. drums, and must be broken up before placing in the mixing tank for admission to batteries: thorough solution should be ensured. The strength of the brine is most important. If the density is not sufficient, the brine will freeze; the correct temperature difference between the brine and circulating air will not be maintained, because with frozen brine there can be no brine rain; and chamber temperature will rise. Freezing brine will expand in the pipes and bursts will result.

A 28 per cent. solution will give a freezing point of minus 44° F. A solution of this strength has a specific gravity of 1·28.

Brine density is usually determined by means of a hydrometer, an instrument sometimes known as a salinometer. This consists of a light glass or metal tube, a few inches long, which terminates at one end in a bulb weighted by mercury, lead shot, or by some other means. When inserted in a liquid it floats with the stem vertical. The depth at which it floats can be read from a scale graduated on the stem, and affords a measure of the specific gravity, or density, of the liquid. Thus, if the instrument floats high in the liquid, the liquid is heavy; if it floats low, the liquid is light. Pure water, at a temperature of about 39° F., is taken as the standard of reference, and has a specific gravity of 1. If a given volume of a certain liquid weighs $1\frac{1}{2}$ times as much as the same volume of water, it is said to have a specific gravity of $1\frac{1}{2}$ or, expressed, as is more usual, in decimals, 1·5.

There are three scales in common use for hydrometer graduations: Ordinary, Baumé and Twaddell. The Ordinary type is easily the most convenient. It gives a direct reading of the specific gravity multiplied by 1,000; or, to look at it another way, the reading divided by 1,000 gives the specific gravity correct to three decimal places. Twaddell and Baumé hydrometers are graduated in "degrees." One degree Twaddell is equivalent to a specific gravity 0·005 above that of water, *i.e.* 1·005; two degrees Twaddell equals a specific gravity of 1·010; thirty degrees Twaddell equals a specific gravity of 1·150; and so on. Thus, to convert Twaddell degrees to specific gravity it is necessary to multiply by 5, add 1,000, and divide by 1,000. Baumé degrees are not dealt with so simply. Their only advantage is that each degree occupies the same length on the scale, whereas with other hydrometers the distances between the graduations differ in different parts of the scale. To obtain the specific gravity of a liquid heavier than water it

is necessary (i) to take the reading in Baumé degrees away from 144·3, and (ii) to divide the answer into 144·3. This operation is so cumbersome that it is better for people using the Baumé hydrometer, or even the Twaddell, to have conversion tables handy. Such tables will be found on p. 226.

As an example: 5 lb. of calcium chloride per gallon of water will give a Baumé reading of about 23°, a Twaddell reading of 38°, and an ordinary hydrometer reading of 1,190. The specific gravity of the solution is therefore $\frac{144{\cdot}3}{144{\cdot}3 - 23}$ or $\frac{5 \times 38 + 1{,}000}{1{,}000}$ or $\frac{1{,}190}{1{,}000}$. It will be seen that each of these is equal to a specific gravity of 1·19. Incidentally, a solution of this strength has a freezing point of two degrees below zero.

Concentrators

The humidity of the atmosphere, which varies with the temperature and the amount of chamber door opening, will affect the brine strength. Evaporation from goods in store and absorption of the water vapour from chamber air will weaken the density. The density can be restored by adding more calcium, but, to effect economy in calcium consumption, concentrators are used. Concentrating is simply the evaporation by boiling of the excess water content of the brine solution.

Any absorption by the brine of water vapour from chamber air increases the volume of the brine. By a suitable connection of the overflow outlet of the brine tank to the concentrator pump, the top of the brine can be pumped into the concentrator tank. A coal, coke, or oil fire beneath the tank will heat and eventually boil the brine. As the boiling continues the density increases. When the density has increased sufficiently, the brine can be pumped back into the system.

The cost of fuel consumed in heating the concentrator tank is always less than the cost of making up calcium chloride, so that a concentrator is invariably included as part of necessary plant equipment.

Air Distribution

To obtain the greatest economy in power, space, and material, the air should be circulated as directly as possible, and at the lowest possible velocity. The volume of air required, the static pressure necessary, and the motive power available are the principal data. Ducts should be free from sharp bends to reduce friction loss. The rate of flow of air through ducts is governed by the pressure applied, part of which is required to overcome the friction and only the remainder of which is available to produce the required speed of flow.

Ducts should always be so designed that their breadth does not exceed five times their depth. Interiors of ducts should be absolutely smooth. All branch connections should be curved. Deflectors should be fitted where necessary. Ducts should be installed along the length of the chamber, not along the width.

Air ducts should be designed so that the air circulation inside the chamber is balanced. The volume of air and the speed should be such that the circulation is throughout every part and corner of the room. The circulation should not be too rapid ; gentle diffusion at a constant rate is the ideal at which to aim.

In the usual plan of air ducting there is a suction duct right down the centre of the chamber ceiling, and delivery ducts down either side. Slides in the delivery ducts are on the sides. Slides in the suction duct are on the bottom.

Design varies between wide shallow ducts and square types of duct tapering towards the extreme end. The area and shape of ducting is governed by the size and shape of the room. No air ducting should be less than twelve inches in depth. Naturally, a streamlined duct with a smooth inside surface and no abrupt corners is desirable. The flow of air should be without friction.

Air ducting is usually made of wood, but asbestos boarding and sheet metal are also used. Sheet metal corrodes, and is noisy. Asbestos boarding is brittle. Tongued and grooved boarding is the material for preference.

CHAPTER 18

CHAMBER TEMPERATURES AND PLANT OPERATION

TEMPERATURE RANGE

STEADINESS of temperature is all important and the temperature range shoul be kept as narrow as possible. A range of 2° from, say, 14° to 16°, is as goo as can be expected in practice ; a range of 10° is definitely bad. Long storag commodities very soon reveal the effect of fluctuating temperatures. Even i chill rooms steadiness of temperature is equally necessary.

Fluctuations are due to excessive door opening, or to long shut-down c refrigerating plant. Door opening is generally due to traffic movement— intakes and deliveries. Careless door opening can, of course, be checked Supervision of deck staff, control of air locks, flapper doors, curtains, and, a is done in some stores, the posting of men or boys with the duty of regulatin the opening and shutting of the doors as trucks move in and out, contribut greatly to reduction of heat losses due to door opening.

Long shut down of plant is due to unimaginative plant running. Som managements believe it is wise economy to run two watches instead of thre and thereby to save the wages of two engine room attendants. Other manage ments believe that running refrigerating plant during the night instead o during the day is more efficient as well as cheaper.

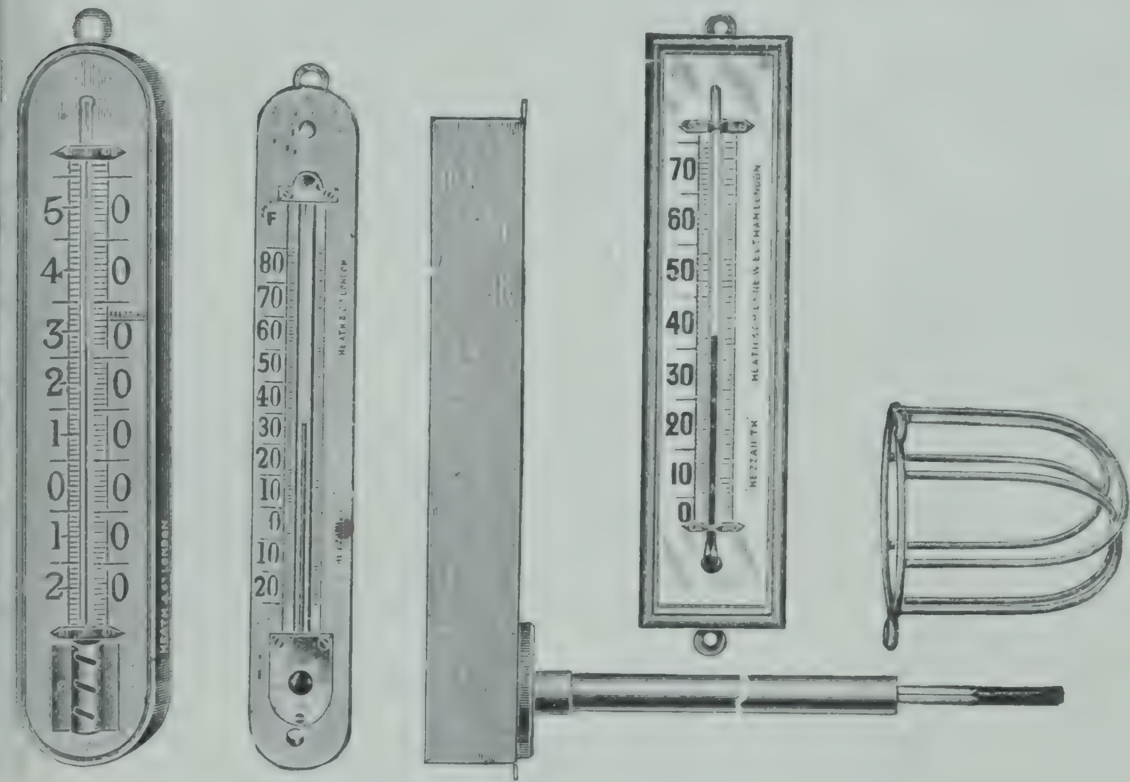
Records prove the fallacy of both beliefs, but few cold stores keep adequat records. Operating cold stores, blindly, that is without records, is foolish foolish and unintelligent. Records are very necessary ; and, for certain records instruments are required. First on the list of instruments are thermometers

TYPES OF THERMOMETERS

For correct chamber temperature readings more than one thermometer i necessary, and the equipment can be an expensive item in any cold store It should be given careful consideration when deciding which types to instal Price, accuracy, accessibility, legibility, and maintenance are the five decisiv factors. The various thermometers available are these :—The all-black meta type with white figuring, or all-white metal with black figuring ; the yellow varnished wooden type with a coloured stem ; the thermometer encased in a wood insert pushed through a hole in the insulation and forming a plug ; th

long-distance thermometer with the bulb inside the chamber and a clock-like dial immediately outside ; the recording thermometer actuated by clockwork and writing a weekly graph record ; and the long-distance electrical thermometer.

If anything, our preference is for the dial-thermometer, but the bulb should be situated much further inside the chamber than is generally the case. The



A B C

[*Courtesy*: *Heath and Co.*

Fig. 32.—Types of Chamber Thermometers.

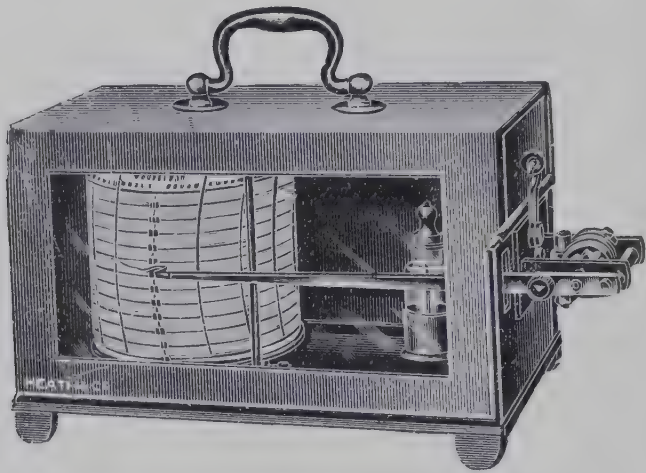
A. 10 in. chamber thermometer of extra wide polished boxwood, with red fluid tube. Very bold dividing and figuring. Range from $-20°$ to $50°$ F.

B. $8\frac{1}{2}$ in. chamber thermometer of polished boxwood. The bulb of the red fluid tube is sunk, thus making breakage difficult. Range $-20°$ to $80°$ F.

C. Right-angle type chamber thermometer in oak case with glass front. Designed for quick reading and as an improvement on the plug type. The bulb projecting into the chamber is protected by a metal guard.

dial-thermometer is easy to read, and the dial, being usually above or near the chamber door on the outside, is the first and last object to claim attention when entering or leaving the chamber. The dial-thermometer has few, if any, disadvantages, but the ordinary wooden thermometer should be used in conjunction with it so that the mean temperature of a chamber can be taken.

Other thermometers have various disadvantages which can be briefl considered.



[*Courtesy: Heath and Co.*

Fig. 33.—Recording Thermometer.

[*Courtesy: Heath and Co.*

Fig. 34.—Wood Plug Thermometer.

[*Courtesy: Heath and Co.*

Fig. 35.—Long-distance Dial Thermometer
The capillary cable may be made of any desired length.

Inaccessibility is a disadvantage of all thermometers not permanentl fixed in an accessible place. The dial and the long distance thermometer ar both outside the chamber, permanently fixed, and always visible. The wooden

insert thermometer is also a permanent accessible fixture. Thermometers hung in chambers are always liable to be hidden or obscured by stacks or stows.

The inaccuracy and the liability to damage of the cheap wooden thermometer are clear to everyone who has had experience of this type. When such thermometers are encased in a wooden plug insert which passes through the insulation, they are unreliable, because the temperature reading is affected when withdrawing the plug through the insulation. Such plugs are seldom air tight and the actual room temperature cannot be shown because of this air passage ; furthermore, the plug is usually near the door.

A recording graph thermometer is mechanically operated usually by clock-work, and is therefore subject to mechanical faults and breakdowns.

The electrical long-distance thermometer is an expensive installation. In comparison with ordinary thermometers, the dial-thermometer is also an expensive item, but it does not need the regular calibration which is necessary with the electrical instrument. Electrical thermometers, also, are subject to electrical faults and consequent need of repairs. However, modern stores usually have an electrical long-distance thermometer installation, together with chamber thermometers of the more expensive metal-cased type.

The advantages and disadvantages of the various thermometer types may be conveniently tabulated as below :—

Thermometer Type.	Advantages.	Disadvantages.
Metal with white or black figuring	Legibility.	Inaccessibility.
Wooden	Cheapness	Inaccessibility. Inaccuracy. Easily damaged.
Wooden, encased in wood insert	Cheapness. Accessibility.	Unreliable.
Dial Thermometers	Legibility. Accessibility.	None.
Recording with graphs ...	Accuracy. Visual Record.	Maintenance.
Electrical long-distance ...	Accessibility. Legibility.	Constant calibration. Expensive.

STORAGE TEMPERATURES

The temperature for storage of meats, butter, and so on has always been accepted as 15° F., but in order to ensure that the centres of the stacks are no higher than 15°, it is necessary that the chamber temperature, as recorded on a thermometer hung in the centre of the room, should be held at 12° at the most. In a large chamber with proportionately larger stacks, a still greater temperature difference is to be feared in different parts of the room, especially in a pipe cooled room. Where meats have at any time been stored for long

periods, the signs of store staleness are usually sufficient to indicate that a temperature lower than 15° is needed. Under normal conditions meats are seldom stored for very long periods. One commodity, however, frequently remains in stores in certain areas, for periods of twelve months. This is frozen egg, and it is deemed advisable where large stocks are held for many months to hold it at a low temperature of 12° instead of the usual 15°.

It is almost impossible for the average store to maintain a temperature range as narrow as from 14° to 16°. A two degrees variation would be difficult to avoid even if chamber doors were never opened. Even new stores will lose a couple of degrees during the usual night shut-down of plant.

Under average plant operating conditions long shut-down periods, especially during the night, are regrettably the rule rather than the exception. Results would be very much better if it were the general practice to hold a low storage temperature, say, 12°, and to maintain a short temperature range. The general practice, however, gives an average temperature of 17° with a range of from 14° to 19°.

The reason for the generally accepted belief that a long shut-down of plant is an economy is hard to understand. Confining plant running to two watches does save the wages of two engine-room operators, but actual power bills are no less, and actual running hours tend to be more. The saving in wages is more than offset by the effect which higher and fluctuating temperatures have on meats and other commodities. These may occasion loss of business due to a reputation for a poor out-turn of goods. And there are such things as claims.

POWER RATES

There are two methods of assessing electrical charges—power cost per ton moved, and power cost per ton stored. In addition, compressor running hours per ton moved and per ton stored should also be recorded. Plant design will, of course, greatly affect these figures, but design is not being considered at the moment.

Given a store with moderately efficient insulation, design, layout, and so on, and refrigerated by a plant of perhaps doubtful modernity but on which no capital expenditure can be even considered, the job of the management is to make the most of it. Operation of the plant must be intelligent, economical, and efficient. False economy at the expense of efficiency is not intelligent.

Consider the cost of power. Most electrical companies make two separate charges: (i) the load or power factor, known in some areas as the K.V.A.; and (ii) the rate per unit of electricity consumed.

The K.V.A. or load factor may perhaps be understood better if an earlier type of electrical agreement is described. This was known as the E.H.P., or the electrical horse power installed. In this agreement, the total horse power of all the electrical motors installed formed the basis of an agreed standing charge. If a total of, say, 500 E.H.P. was installed in a cold store,

[*Courtesy: Trafford Park Cold Storage Co., Ltd.*

Fig. 36.—Recording Instruments in a Fruit Storage Chamber.

the standing charge might be 3/- per horse power per year, and a rate of 1d. per unit consumed. If the total of the electrical horse power installed was only 100, then the standing charge would be 4/- per horse power, and $1\frac{1}{2}$d. per unit consumed. The greater the total of installed horse power, the cheaper the electrical rate.

The load factor or K.V.A. is a similar standing charge. The standing charge is so much per K.V.A. for the highest K.V.A. recorded during the year. There may be a great difference between the highest K.V.A. and the average K.V.A. The peak may have been reached for an hour or even less, but the charge will be assessed on that recorded peak for the year. The rate per unit consumed is, of course, fixed, and is usually low.

Therefore, intelligent plant running implies so balancing your compressor load that only the lowest electrical load will be called for. Without considering other factors, let it be understood that compressor running hours are not so important as compressor load. In other words, twenty-four hours running with one compressor is cheaper and infinitely more efficient than twelve hours running with two compressors.

ELECTRICAL DEMAND

It should never be forgotten that power rates are based on maximum demand. Maximum demand should be kept as low as possible. Most refrigerating plants in cold stores have at least two compressors, one of them usually being in reserve. There may be times during the summer season when the refrigerating load is such that it appears necessary to run the second compressor, but the K.V.A. should be fully considered before doing so. Two compressors running together will increase the maximum demand. The electrical charge for the rest of the year will be based on this increased rate of consumption which may be necessary for only that one day. Again, when changing over from one compressor to another, the engineer may thoughtlessly start the second compressor before stopping the first. For a short time only, perhaps, the demand on the electricity supply may be doubled. This will increase the electrical rate. The K.V.A. meter requires checking daily.

Some managements have wires with lead seals affixed to their reserve motors so that it is impossible to start the motors without breaking the seals. Occasionally even efficient engineering staffs can be thoughtless.

SUCTION PRESSURE

Examination of the engineer's daily log sheet or, better still, of the compressor suction gauge, will show variations from high to low. If the chamber temperature is high the suction pressure will be high, and will gradually be reduced with the chamber temperatures. Without going into technicalities, the compressor load is reduced with compressor running. A thirty ton refrigerating capacity compressor may be driven by a fifty electrical

horse power motor. Compressors are designed to run at a certain speed with a maximum suction and head pressure. Given these, the compressor has a certain refrigerating capacity, or in other words, is capable of extracting a certain number of British Thermal Units per hour. The electrical motor has been designed to run at a certain speed and to be capable of an output of so many horse power at a consumption of so many units per hour.

IGINE ROOM LOG — NORTH HAVEN COLD STORAGE CO. LTD. — 24 HOURS ENDING 8.00 A.M. 194

PLANT			TIME	CHAMBERS									
	OMPRESSOR NO. 1 $7\frac{1}{2}'' \times 7\frac{1}{2}''$	COMPRESSOR NO. 2 $9'' \times 9''$		GROUND FLOOR PIPES			FIRST FLOOR AIR			SECOND FLOOR AIR		THIRD FLOOR PIPES	
				1	2	3	4	5	6	7	8	9	10
CK SS.			8·00 A.M.										
ND. SS.			12·00 NOON										
ME TED			4·00 P.M.										
ME PPED			8·00 P.M.										
ER N			12·00 MDNT.										
TER FF			4·00 A.M.										
INE MP.			REMARKS:–										
NE SITY												ENGINEER	

			AMMONIA CYLS.	CALCIUM DRUMS	REFRIG. OIL GALLS.	ENG. OIL	WASTE LBS.	LAMPS 40W
PS								
MOS.	% HUMIDITY		IN STOCK					
	POWER METER	LIGHT METER	WATER METER	REC'D.				
-DAY								
TERDAY				CON'D.				
SUMPTION				BAL. STOCK				

Fig. 37.—Specimen Engine-Room Log Sheet.

As the compressor suction pressure is reduced with the lowering of the chamber temperatures, the refrigerating load is reduced, and the demand for electrical horse power from the motor is correspondingly less. But the maximum demand meter will vary little.

PLANT OPERATION

From the preceding paragraphs it will be obvious that little is to be gained by running compressors for long periods alternating with long shut-down periods. The average chamber temperature is higher, the cost per compressor

hour is higher, the cost per ton moved, and the cost per ton stored are higher. The liability for mould and poor out-turn of commodities is greater.

The engine room log sheet is an important daily record. Managers need not necessarily be engineers or technicians to understand a log sheet. Most managers look at the chamber temperatures, but there are a great many interesting and important data on a log sheet that directly concern the manager. Listed, they would be :—

1. Meter readings.
2. Total compressor running hours for the day.
3. Times of starting and stopping of compressor.
4. Suction pressure and gas temperature.
5. Condenser pressure.
6. If air cooled chambers—brine temperature and air temperatures, in and out.
7. If brine cooled pipe chambers—brine temperature, in and out.
8. Chamber temperatures.

It will be noticed that chamber temperatures appear last in the list. Chamber temperatures will take care of themselves if the plant operation is intelligently regulated.

There is a definite relationship between items 4 and 8, and these are controlled by items 2 and 3. Reduction in item 1 cannot be effected without affecting all the other items. Item 1 represents cost. Item 8 represents reputation and efficiency.

Staggered Running Hours

Consider the following two methods of plant operation over twenty-four hours :—

A.

Compressor	started	10 p.m.	Chambers	Temp.	Average,	19° F.
,,	stopped	6 a.m.	,,	,,	,,	13° F.
,,	started	2 p.m.	,,	,,	,,	22° F.
,,	stopped	5 p.m.	,,	,,	,,	20° F.

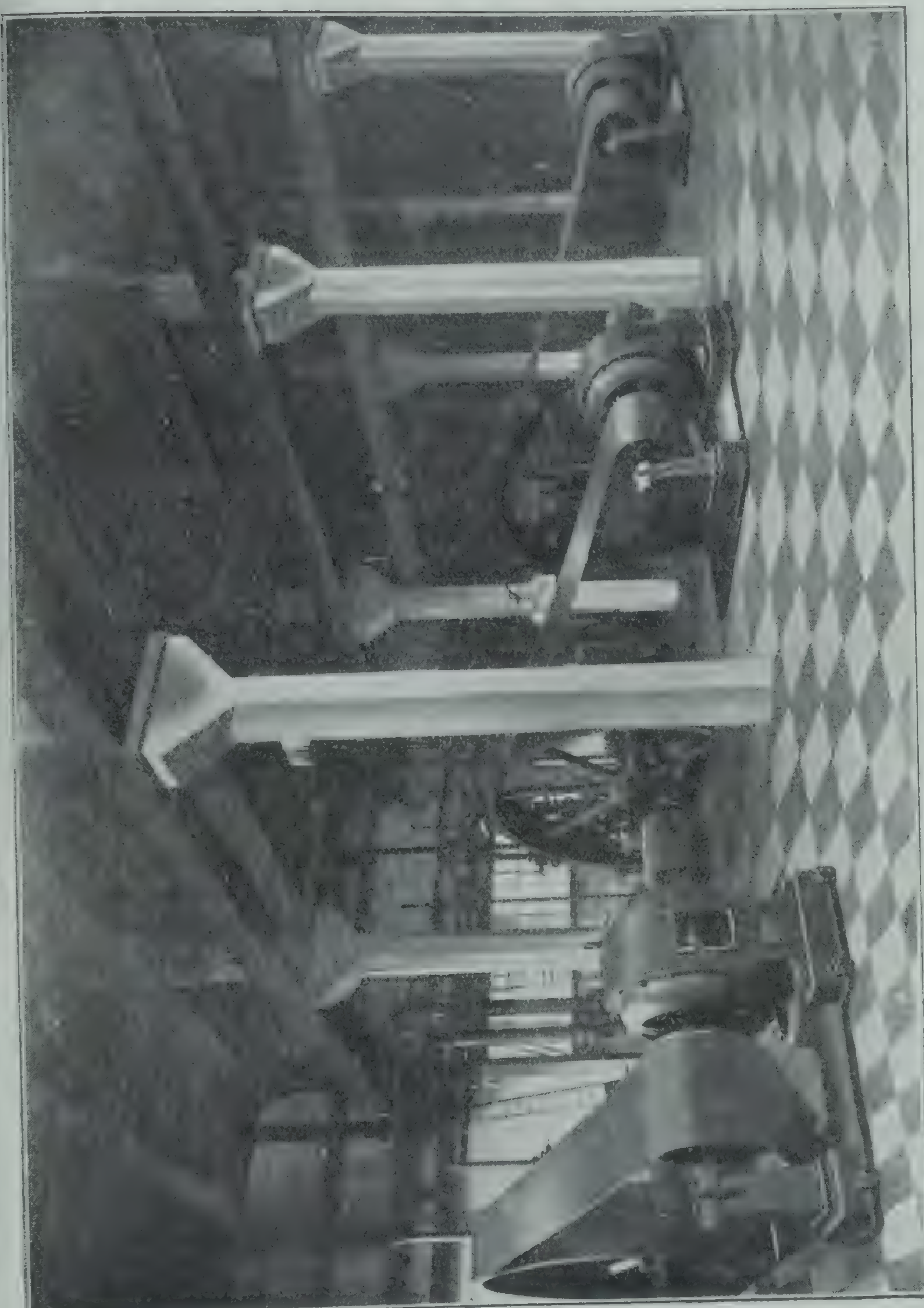
Total hrs. run—11 hours. Av. Ch. Temp., 18° F.

B.

Compressor	started	12 mid.	Chambers	Temp.	Average,	14° F.
,,	stopped	3 a.m.	,,	,,	,,	11° F.
,,	started	6 a.m.	,,	,,	,,	13° F.
,,	stopped	9 a.m.	,,	,,	,,	11° F.
,,	started	12 noon.	,,	,,	,,	15° F.
,,	stopped	3 p.m.	,,	,,	,,	13° F.
,,	started	6 p.m.	,,	,,	,,	15° F.
,,	stopped	9 p.m.	,,	,,	,,	12° F.

Total hrs. run—12 hours. Av. Ch. Temp., 13° F.

Under scheme A—one hour's running, and the wages of one shift or watch are saved.



[*Courtesy: Trafford Park Cold Storage Co., Ltd.*

Fig. 38.—Cold Store Engine Room.

Under scheme B—an extra hour's running and the wages of one engine room watch are incurred, but five degrees difference in average chamber temperature is obtained with all the benefit of the better storage conditions which that implies.

The above comparison is taken from the engine room log sheets of an actual plant. After two weeks trial of scheme B it was found that the extra hour's running could be saved by modifying each of the compressor starting times to a quarter past the hours given. Incidentally, it was also found that with the shorter but more frequent running periods the temperature rise tended to be less as time went on. After one month's trial of the staggered running hours system, the average chamber temperature throughout the twenty-four hours was 12° F.—one degree less than that shown.

A similar trial was effected in air cooled chambers and even greater benefits and advantages were demonstrated. It was discovered that by working the cooler fans, without the brine pumps, at a slow speed, in the middle of each shut-down period, temperatures were stabilised. If the compressors are shut down between 12.00 and 3.00, the fans should be operated from 1.00 to 2.00. In other words, the fans should be operated much longer than the compressors.

The flexibility of plants varies. Generally speaking, plant operation should be based on short and frequent running periods. The twenty-four hours of the day should be split up into eight periods of three hours rather than two periods of twelve hours.

One other important point. If for any reason, such as hot and heavy intakes, excessive door opening, sudden increase in atmospheric temperature, or a temporary breakdown of refrigerating plant, chamber temperatures have risen out of hand, then the plant should be run continuously until temperatures are back to normal. Too many engineers are tempted to catch up on temperature losses over a long period. It is a foolish policy. Temperature losses must be regained as soon as possible.

To sum up: The policy of all normal plant operation should be "little and often." When conditions are abnormal the policy must become "Continuous running." Above all, records must be kept and checked: they will be constantly needed for reference and analysis, and any variations they reveal should be fully investigated.

Automatic Plant Operation

To ensure successful operation the tendency is to instal plant which automatically controls the temperature within a small range. The automatic control of large plants is a fairly difficult matter, though far from impossible; with small plants it has already achieved excellent results. Electric current for driving the motors is switched on and off by a thermostatic switch and a four-degree temperature range thus maintained within the chambers.

CHAPTER 19

GENERAL MAINTENANCE

MAINTENANCE of the building, of the plant and its auxiliaries, and of all equipment, is quite definitely an important part of cold store operation. Without it, repairs and renewals can be frequent and give rise to heavy expenditure. With it, economy can be effected. Probably in no other industry is maintenance so necessary, and there must be few industries in which wear and tear are so heavy as in cold storage.

Maintenance does not consist of repairs after breakdowns. Maintenance means repairs to prevent breakdowns. It cannot be adequately carried out unless systematic methods are adopted, or unless comprehensive records are kept. There are three necessary rules:—

1. Examination.
2. Investigation.
3. Recording.

Examination

Every part of the building, every item of plant, every piece of equipment should have an identity number. This number will appear in the official maintenance record book, and should also be shown on a label attached to the article concerned. The date of the last examination should be shown with it, and will, of course, be posted in the book.

Investigation

Investigation should be made into every breakdown, failure, or fault in working, and a full report should be included in the individual history of each item. This report will be entered in the maintenance record book.

Recording

Reports on examinations and repairs cannot be too full. The head of each department will keep a rough maintenance report book and will furnish the office with his reports of examinations, repairs, and renewals. These will be written up, or typed, on individual sheets in the official maintenance record.

The official maintenance record can be kept either in a loose leaf book or in a card index. On the whole, a loose leaf, leather bound book is preferable for a permanent record. It should be fairly large, approximately 15 in. by

18 in., and divided into three main sections for building, plant, and equipment. Each main section will be sub-divided. An alphabetical index should be provided and each sheet numbered for one item. Each sheet should be divided in columns with the following, or similar, headings :—

Date of Examination.	Report on Examination, Repairs or Renewals.	Amount of Deprecia-tion.	Cost of Repairs.	Present Value.

This combination of headings, together with the arrangement of one numbered page for one numbered article, ensures that (i) no item of equipment or plant can be omitted from examination, (ii) a permanent and complete current stock list is always to hand, and (iii) depreciation accounts cannot be balanced or closed until every item has received attention.

ANNUAL EXAMINATIONS AND OVERHAUL

Buildings

Walls should be examined for cracks, bulges, settlement, pointing (if brick), condition of damp-proof courses, choked gutters and spouts. Roofs should be examined for leaks, broken tiles, etc. The woodwork of windows and doors should be carefully searched for cracks, broken hinges and fittings. Paintwork should be examined for the effects of weathering. Steel and iron work should be thoroughly gone over for signs of corrosion and pitting. The road or yard should be examined for wear and settlement. Drains should be cleared, gates re-swung and adjusted.

Floors

Loading banks, staircases, and chamber floors should be inspected for cracks, pitting, holes, and the results of general wear and tear. All holes and cracks should be re-cemented ; they slow down handling speed, and cause breakage of truck equipment. If possible a special hard surface should be laid. Filling in holes and cracks is at best a temporary expedient and, sooner or later, has to be repeated. Laying a special, hard, granolithic surface is, in the long run, an economy. The wear and tear of floors by the constant passage of trucks is extreme.

Chamber Doors

Any cold store chamber is as efficient as its weakest point, and the weakest point of any chamber is the door. No other part of a cold store requires more constant maintenance.

In the average recently designed cold store of, say, 200,000 cubic feet capacity there are at least a dozen doors. In an older type store of similar size, with smaller chambers, there will be double that number. A carpenter and his mate will find their time fully occupied in maintaining them in perfect condition.

There are three items in connection with doors that are important : gaskets, hinges (and adjustment of door to door frame or lintel), and door fittings.

Gaskets do not require repairs ; they require renewal. They should be renewed whenever found faulty. Particular attention should be paid to that part of a gasket on the bottom of a door. Icing up of doors does considerable damage to gaskets ; tearing, flattening, and distorting them. They should be constantly smeared with a non-freezing oil ; this prevents icing up, to a certain extent, and preserves their flexibility. There are various forms of gasket, and the more expensive kinds have the longer life. But twelve months of constant door opening and shutting takes the life out of even a good gasket.

A chamber door, because of its dimensions and insulation, is fairly heavy, yet it must swing easily and fit perfectly. Its hinges should therefore be kept freely lubricated and any wear adjusted by means of additional washers or new pins, depending on the type of hinge and the means of adjustment. With modern hinges adjustment is rendered easy by means of an adjusting screw.

Owing to the temperature difference between the inside and outside of a door, warping and distortion can be expected and must receive attention. Not to give this attention is to encourage the use of crowbars, banging with trucks, and other means of opening doors which fit badly. Sticking doors also slow down handling.

Dirt collects on and around door sills and unless constantly cleaned away will form a nucleus for ice blobs, resulting in eventual strain on door fasteners.

Door fasteners are of various types. The modern types are spring loaded, can be actuated from either side of the door, require but a touch to release the fastener, and combine a padlock attachment. The older types are without springs, are easily strained, and can be operated from one side of the door only. Door fittings will stand up to a great deal of repair, but occasionally it is more advisable to renew them completely. An inefficient door fitting, a badly swung door, a broken or flattened gasket, all indicate thermal losses, and interference with handling rhythm. Thermal losses and obstruction to handling, no matter how small, increase operational costs, and reduce profits.

Curtains and Flapper Doors

Curtains and flapper doors are installed to reduce thermal losses when the main chamber door is standing open during loading or unloading of the chamber. Curtains very soon get torn and/or iced up. They should be hung so that they are easily detachable—a simple matter of hooks and ringed eyelets. A spare pair of curtains should be available to exchange, at any time, for those in need of repairs. Most carpenters can use a sailmaker's palm and needle, and patches are a simple matter. Where curtains are iced up, thawing out and drying can be completed in a couple of days. Renewals of possibly one or two curtains may be necessary each year, and should not be stinted ; an inefficient pair of curtains is of no use whatever. Spare curtains are therefore necessary in the equipment store of every cold storage warehouse.

Flapper doors do not as a rule need much maintenance. The ball bearing pintles or spigots, on which the flapper doors swing, occasionally need grease but seldom renewal. The convex and concave gaskets of the two doors usually have a very long life. Plates are advisable on both sides of the doors for, at least, half the height. These, however, should be fitted on installation.

Insulation

In the old days of loose insulating materials it was customary to remove the top board occasionally and examine for settling. If an empty space proved that settling had occurred, more loose cork or slag wool was packed in. In these days of slab corkboard there is little danger of settling, and consequently insulation is very seldom examined. Defective insulation advertises itself in various ways—particularly in the summer months when the atmospheric temperature has risen sufficiently to make the temperature difference between either side of the insulation in the region of 65° F.

An insulant composed of loose material will absorb a certain amount of warm, humid air from the outside atmosphere. This air will be greatly cooled in the insulant, as it approaches nearer to the low temperature region inside, and condensation of its water vapour content will result. The condensed moisture will continue to accumulate until the quantity entering is in equilibrium with the quantity evaporating ; and, since the rate of evaporation at low temperature is slow, it will not be long before the insulant is saturated. By then the insulation will have broken down, for water has a high thermal conductivity. It is therefore apparent that the nature and structure of an insulant are very important.

It is a common experience in cold stores to note the sudden appearance of damp patches on the outside of cold store walls. Drips, and sometimes, pools of water appear in corridors and passages. Inside the chambers, icicles begin to grow. As the atmospheric temperature decreases these damp patches disappear ; they re-appear, however, as soon as the atmospheric temperature rises beyond a certain point. Opening the insulation where the damp patch is showing usually reveals a saturated cork slab, but this is no indication of the actual locality of the insulation leak or weakness, and to trace this weak spot is usually an impossible task.

Thermal weaknesses may be due to a number of causes, but usually the cause is insufficient sealing. All that the cold storage operative can do, however, is note the time and locality of any indications of thermal weaknesses on the outside of insulated walls. It is also a good plan yearly to open up a portion of the insulation, say about a foot square, at a different position each year, and to make a full report on the condition found. In any case of suspected weakness it is advisable to call in an insulation expert at once. He may be able to trace the cause and take steps to prevent it developing. Insulation trouble can be the most expensive trouble cold storage operatives may have to face, and it may involve complete re-construction.

Lifts

Many cold stores have a contract for lift maintenance with a firm of lift engineers who regularly visit and repair lift installations. Usually, this is advisable ; for, although all cold stores have an engineering staff, few refrigerating engineers possess lift experience or knowledge. However, inspection, and a certain amount of maintenance of parts not covered by the maintenance contract, is still necessary on the part of the cold store staff. The care, maintenance, and operation of lifts is covered by various clauses in the Factory Act, and strict attention must be paid to the requirements laid down. These clauses are, of course, exhibited in every cold store, or in any building with a lift.

The more important parts of a lift installation to necessitate frequent inspection and maintenance are the ropes, the guide rods and shoes, the brake, controls, motor, operating panel, and gates (particularly, gate locking devices and electrical contacts). Carbonisation of contacts and slip rings on the motor, wear on ropes, guide rods, and shoes, distortion of gates rendering electrical contacts ineffective, and so on are the usual points to watch.

An important point to remember is that when any lift is under repair, a notice to that effect should be exhibited on each lift gate at each landing or floor. This may appear unnecessary, but it is a wise precaution against accidents.

Trucks

Maintenance work on trucks is constant and, in most cold stores, the engineering staff are daily repairing at least one truck. The need for repair is most frequently occasioned by bent shafts and broken wheels. Uneven floors break a great many wheels. The screws and bolts securing side rails slacken or are sheared by the constant throwing of carcases and cases on to the truck, and these require continual tightening or renewal. The brackets supporting shafts slacken and break. Breakage can be avoided if the brackets or lugs are examined often enough for any slackening to be adjusted. Cleaning is always necessary. The condensation due to the change of temperature to which trucks are subjected in their journeys in and out of chambers causes corrosion. If the trucks have wooden floors or platform bases, fat and dirt will accumulate on the wood. The weights of trucks must be frequently examined otherwise all tares will be affected, and checking errors will be many. Annual painting is advisable, and this will involve the re-stencilling of the truck number and the individual tare weight.

Condensers and Cooling Towers

If condensers are of shell and tube or double pipe type, their location will be in the engine room, and they will be included in the maintenance of engine room plant. Where condensers are of the atmospheric type, their location is usually on the roof, and they are generally listed as outside the maintenance province of the engine room and distinct from engine room plant.

The necessity for cleaning double pipe and shell and tube condensers, and removing the encrustation on atmospheric condensers varies with the nature of water used. The mains water of some towns gives a considerable but easily removable deposit. Other town waters form a hard and thin scale which requires quite a lot of scraping. Well waters also differ in the nature and action of their deposits. Some simply reduce the effective condensing surface by clogging and acting as an insulant. Others set up an excessive corrosion resulting in pitting.

Not many installations use sea water, but at one store it was found necessary to inject chlorine to prevent clogging caused by an accumulation of mussels. At another store, settling tanks and filters were necessary to counteract the insulating effect of mud deposit. River and canal waters are circulated on many plants. When such waters are used special precautions must be taken to offset and prevent damage caused by the acids and chemicals contained in these waters.

It follows, therefore, that an analysis of the circulating water used is necessary periodically to make sure that the condenser efficiency is not being impaired.

Atmospheric condensers are not usually sources of trouble. Liquid and hot gas valves require occasional attention to their glands and spindles. The water distributing trough, pipes, and spray plates require clearing, and the tank should be emptied and cleaned. Usually, it is sufficient to examine all valves once a year, to repack any glands that may be leaking, and grease all valve spindles. Clean, examine, and repair all spray plates, combs, and troughs. Brush down and repaint with bitumastic paint all pipe surfaces. Brush down, and repair any broken louvres of the woodwork surrounding the condenser. Then paint woodwork with creosote. Empty out the tank, clean, and paint with bitumastic, and fill it up again.

Cooling towers, being mainly woodwork, require thorough cleaning of all trays, etc. Green fungus and other water growths should be thoroughly brushed off. All woodwork should be examined and re-creosoted. Any pipe work should be painted with a coat of bitumastic.

Compressors and Plant

The annual opening up, examination, and overhaul of any plant follows a recognised procedure with which any engineering staff will be familiar. The maintenance of a refrigerating plant will therefore follow the customary steps, the compressors, pumps, valves and auxiliaries being examined for the usual wear and tear, and the usual adjustments made. One item that may get overlooked, and to which attention should be drawn, is the amount and the condition of the gas charge. With an ammonia compressor plant, the best results are obtained with a full charge of ammonia as pure as possible. After long running throughout the summer months, the ammonia charge can be seriously depleted by leaks. It can also become oil logged ; impurities and

foul gases can be mixed in the system. The winter is a good time to purge the system, and to regenerate the ammonia charge ready for the coming season. For, during the winter, the chambers have a low occupancy, and compressor running hours are low.

General

It will be seen from the foregoing that the work of maintenance in a cold store is particularly important, and must claim a great deal of attention. It forms a principal part of cold store operation and, if carelessly done, very soon affects the smooth working of the business.

Only the principal items calling for regular maintenance have been mentioned in these notes, but there is always something to be done, and in most stores it is difficult to keep abreast of the regular maintenance work. Emphasis has been made on the need for accurate and regular record keeping. Records are almost as important as the maintenance work itself.

CHAPTER 20

MOULD

MOULD and vermin destroy more food than anything else known, and are the two greatest problems of the cold storage industry. Of the two, mould is the worse. It spreads with astonishing speed and creates a tremendous amount of havoc if not checked. Meats and other goods affected by mould in cold storage must be condemned, which means a great loss to be borne by the cold store proprietors. It is therefore everyone's duty in a cold store to be able to recognise mould, but it is usually the manager or superintendent of the store who makes it his special and regular duty to look for it.

Mould begins with the appearance of small white spots which grow larger, multiply, and eventually turn black. The black mould will penetrate ever deeper into the meat, turning it sour. Trimming and cutting out the spots, if done in time, may arrest the mould growth and allow the remainder of the meat to be saved. Otherwise, nothing can be done about it ; condemnation and destruction are inevitable.

It is certain that mould is fostered by humid conditions ; it cannot germinate save in the damp. Once it has germinated, however, it will develop and spread rapidly. Dampness in chambers can be caused only by condensation, and it is most important to ensure that condensation is at a minimum. A certain amount cannot be avoided : hot air admitted by door opening meets the cold chamber air and causes precipitation of moisture, especially near the doorway. But it is well within the power of the cold storage operator to avoid that condensation which is due to fluctuating temperatures. It cannot be stressed too often that fluctuating temperatures must never be allowed.

Another point which deserves careful consideration is that an otherwise perfectly dry and well cooled cold storage chamber may contain a stagnant air-pocket where conditions are ideal for mould development. The danger of these " dead pockets " is not generally realised. They may be avoided by efficient stowing and stacking, which guarantees thorough ventilation.

MOULD IN COLD STORAGE

One of the principal contributory causes of mould in cold stores is undoubtedly defective insulation. Where there is an insulation breakdown there usually follows a discovery of mould. Meats in contact with, or near to, a poorly insulated wall will tend to thaw and decompose. Air circulating near the wall will rise in temperature, its moisture content will increase, and a damp

humid condition will develop, ideal for the germination and the fostering of mould. Also, as we saw when discussing maintenance, a poor insulant will accumulate moisture. We noted that this effect is likely to be greatest in the summer, and it is then that the first signs of it appear. Damp patches and icicles develop on the walls and conditions are ripe for the growth of the dreaded fungus. That this should be at a time when the chambers are most probably full, and when the opportunity for repairs is remote, is an added disadvantage and a further reason for ensuring, right from the start, that the insulation is as perfect as it can be.

Although knowledge of the causes of insulation failure is far from complete, it is true to say that insulants would give a great deal less trouble if more care and attention were bestowed upon their erection. The usual fault is insufficient sealing. Even a good insulant, if badly sealed, will absorb a certain amount of moisture by the process known as "breathing." Breathing is due simply to the expansions and contractions caused by changing temperatures. The insulant is compacted of individual small portions and, as these contract, so humid air is drawn into the spaces between them ; as they expand, so the air is expelled, but much of the condensed moisture remains in the insulant.

Sealing, of course, is the responsibility of the builders, but it is best for the cold store proprietors to satisfy themselves that the work is properly executed. They will realise that the insulation of their store is as important as the refrigerating plant, and that any faults in its erection may not be discovered for years.

Cork boarding should never be placed in direct contact with an outside brick wall ; bricks are porous—some types more than others—and rain seeping through them will soon saturate the cork. The layers of cork board should be sealed from the wall, and from one another, by erection in hot bitumen. A waterproof cement, or bitumastic, may be used instead.

It is also important that steel columns, girders, and beams, should be effectively sealed ; and this applies with particular force to columns which, since they must pass through the ceiling of the top floor to support the roof, provide danger points from which moisture may spread throughout the entire insulation of the building. Sealing, in this case, is thus seen to be necessary quite apart from the good heat-conducting properties of steel.

Assuming that the building, with its insulation, has been properly constructed, the periodical examination and testing of the insulation will still be important. Examinations should be made in the summer when the strain on the insulation is at its greatest, and the temperature difference at its highest. The cause of a damp patch, a drip, or an icicle should be investigated and traced immediately.

Tight Stowage

A lesser, but still important, contribution to the formation of suitable mould conditions comes from incorrect stacking.

Stacks of meat or cases must not be stowed too tightly, or made so high and bulky that they baffle the air circulation in the chamber. Goods on the outside of a large, tight stack may be cold enough, but goods in the centre are liable gradually to increase in temperature, thaw out, and decompose. Ample floor dunnage, laid correctly as described on p. 53, and ample 'tween dunnage must be used. It is most important, and it cannot be repeated too often, that the air should be able to circulate below, around, above, and through the stack. In a tight stack meats in the centre can retain their temperature only by contact with neighbouring cases or bags.

It is interesting in this connection to try a spear thermometer in different bags of the same stack. Those in the centre can be as much as four degrees warmer than those on the outside. Mould development is slow at 14°, but can be rapid at 18° F.

Dirt

Accumulation of dirt in corners, particularly in chambers with timber-faced walls and floors, fosters mould germination. Sweeping out after every traffic movement, and a light sprinkling of lime dust on the floor can be recommended. Goods brought into store in wet or soft condition may develop white mould before hardening. Uncleansed bloodstains breed mould spores. Sweating and dirty dunnage will also contribute mould.

STEPS TO TAKE ON DISCOVERY OF MOULD

It is the usual practice of those in charge of cold stores daily to examine a percentage of the stored goods. A pocket knife and an electric torch are the tools used, and the meats are exposed by ripping open the cloth and hessian wrappings. Usually only those bags on the fringe of each stack will be examined, the light of the torch being shone on all the likely places for mould development.

With quarters the places to search are the flanks and undersides. With boneless beef, if at all possible, the light should be thrown on the centre of the quarter, and near where the meat has been folded over. With carcases, the light should be used inside the carcase, entering from the neck end. Lamb and sheep carcases develop mould much sooner than beef or pork meats. Lambs, particularly, should be carefully watched. When a lamb or sheep is killed, it is hung neck downwards, so that the blood drains out while the carcase is being dressed. If the dressing is careless or indifferent the neck will be extremely bloodstained, and it is here that mould germination usually starts.

In the torch light, mould spots will be revealed as minute white spots. Care must be taken to ascertain that such white spots are not fat. If the spots are mould, there is often a trace of the fine, hairy, or spider web-like fungus growth.

If a trace or any indication of mould is revealed, the whole stack must be examined to find the extent of the spread.

The affected quarters or carcases should be wiped immediately with a cloth dipped in a weak solution of permanganate of potash. The solution must, of course, be weak enough not to discolour or taint the flesh.

If the mould is very advanced, the spots will have to be trimmed, *i.e.* cut out, until no trace of them remains. If this is done in time, the spread can be arrested, and further damage prevented. It must be understood, however, that any meats which have been touched with mould should be examined daily, until they are taken out of store, which should be as soon as possible. Even after wiping down, and the removal of all mould spots, there is every possibility that the mould will re-develop.

If the mould, when discovered, has already turned to the black spots of deep penetration, it is impossible for the stores staff to do anything. The meat will have to be officially inspected and condemnation certificates written out for the weight. The meat will then be taken out of store and destroyed.

So soon as a chamber which has held mouldy goods is empty, cleansing and disinfecting should be put in hand, and this work must be thorough.

Any store, even the newest, most modern, and cleanest can have mould. Meat being received into store may already be infected with mould spores.

The accusation of neglect or of bad cold storage practice will not be made against a store discovering indications of mould spores. It will, however, be made against a store where mould is allowed to spread: that is the crime. Every store should arrest this spread. Neglect, and bad cold store practice, is evidenced when mould is not discovered until it is too late to save the meats affected.

INVESTIGATION INTO CAUSES OF MOULD

As soon as mould has been discovered and the requisite steps taken to prevent further spreading, investigation into the causes of the germination should begin. It must be ascertained and proved whether the mould originated outside, before the affected goods were brought into store. This will be difficult but full enquiries should be made. The rest of the goods in the chamber and in the different stacks must be carefully examined so that any question of mould spores germinating on certain meats and spreading from them to other goods can be settled.

The temperature history of the chamber since the affected meats have been in store must be examined. An average temperature for the whole of the period must be calculated, and a graph made from the log sheets in order to determine the range of the temperature and its fluctuations. If the room is air cooled, thermometers should be piaced in all parts of the room and readings taken in order to make certain that the air circulation is adequate, particularly in that part of the chamber where the mould was discovered. If the room

is pipe cooled, the pipe cooling surface area in the affected part of the chamber should be calculated to make quite certain that no "dead" pocket exists. Tests should be made of ceiling, floor, and wall insulation to ascertain its condition. The thickness of snow on the pipes, the condition of air circulating through the ducts, the possibility of undue condensation having taken place, and the cause thereof, should be examined, and all data and details furnished to form the necessary report.

The position of the dunnage, its cleanliness, condition, and quantity, should be reported on. The cleanliness of the chamber; whether there are, or have been at any previous time, indications of the presence of mould; whether there are any old bloodstains not thoroughly cleaned, and so on.

Lines of investigation can be many and can lead in various directions. Generally, however, the two principal and most frequent causes of mould germination are fluctuating temperature and inefficient insulation. Inefficient insulation, of course, can be a direct cause of fluctuating temperature, but incorrect plant operation will cause fluctuating temperature whether or not the insulation is in perfect condition.

PREVENTION OF MOULD AND PRECAUTIONS AGAINST IT

It will be seen that to prevent mould, everyone on the cold store staff can contribute. Every cold store operator should be fully conversant with the possible causes of mould, and should consider it a part of his duties to eliminate such causes as much as he can.

The engineer, by wise operation of the plant, can ensure steady temperatures. The warehouseman, by his use of dunnage and by correct stacking methods, can ensure equal distribution of the temperature all over the chamber. The foreman and checker can ensure that the goods being received into storage are in a fit and proper condition. The stock clerk can ensure that no goods remain in store unduly long without attention being drawn to the fact.

Despite these precautions it is nevertheless possible for mould to germinate. The only prevention against such germination being allowed to develop and spread is constant daily inspection of all chambers, and of all goods in store. To the above list we may therefore add: The manager or superintendent, by his constant daily inspection of the chambers, can ensure that no mould is being developed or spread. Let it be remembered that widespread mould in any cold store implies neglect.

CHAPTER 21

REVENUE. RATES AND CONDITIONS OF STORAGE

REVENUE

THE revenue of any cold store is derived from its charges for the storage of commodities and for various operational services. The charges for storage should be such that they will cover all operating costs, depreciation on plant and buildings, rents, taxes, and other expenditure. Many cold stores, however, actually work at a loss, and survive only because they are run in conjunction with other businesses, and it is the allied businesses which make the profit.

Assessing the actual operating cost of each individual consignment of goods received for storage is rather difficult. Goods are received at different times, in different circumstances and in different condition. Operating costs on goods received in summer are much higher than on goods received in winter. Some consignments are received in soft, unfrozen condition, and a tremendous amount of latent heat must be extracted. At other times goods are received ex ship in a fairly hard frozen condition, and little extra refrigerating load is required.

The larger a cold store, the lower the operating cost per cubic foot, or per ton stored. The average all round operating cost of a cold store above 100,000 cubic feet capacity works out at approximately 0·4 pence per cubic foot per week.

To effect a greater profit margin, it has been usual to attempt a reduction in operating costs rather than to increase cold storage rates. Increasing charges has been made difficult by the competitive rates ruling at more economically operated stores. For this reason cold storage charges seldom appear to have any scientific basis.

There are many factors which enable certain cold stores to offer lower rates than others, and these should be taken into consideration when a new store is to be built. Some of the more obvious of the factors are : suitability of the store for local requirements, adequate handling facilities, large capacity, economical operation, and proximity to railways, or to ports and docks.

Division of space must be made to meet the needs of the various businesses of the locality. To decide the required proportion of storage rooms to chill rooms, the capacity of these rooms, and their position relative to the loading bank, requires experience and knowledge of local conditions. Alterations may be necessary each year to suit varying conditions and commodities ; for, according to the design of the store and its handling facilities, the warehousing of certain commodities may be either profitable or an expensive proposition.

For the same reasons, storage rates for these commodities may be either low or high.

Stores are usually designed with a three to one ratio between storage space and chill room space. Loading bank and corridor space should approximately equal seven per cent. of the total floor area. Lifts and conveyors should be installed on the assumption that one lift is necessary for every 50,000 cubic feet in stores under 1,000 tons capacity, and that one lift per 100,000 cubic feet is usually sufficient in stores between 1,000 and 6,000 tons capacity.

These considerations may appear irrelevant, but actually they bear a close relationship to revenue and operating costs. If, because of competitive rates, storage charges cannot be increased, then operating costs must be reduced. Refrigeration and handling costs are the principal items in operating expenses, and the design and equipment of a store influences both.

Storage Capacity of Chambers

Every cubic foot of insulated space represents a potential source of revenue, and it is obviously best to try to fill it. However, certain commodities, because of their peculiarities, take up more space than others. It is apparent then, that storage charges must vary according to the nature of the commodity.

In assessing the storage capacity of any cold store, it is usual to reckon at 130 cubic feet to the ton. Thus, a 1,000 tons capacity store will be a store of 130,000 cubic feet, and a store of 250,000 cubic feet will be said to have a capacity of 1,923 tons.* On this basis, if a cold store charges 30/- per ton per month for storage, then a 1,000 tons store should have an annual revenue earning capacity of £18,000, twenty-eight days counting as one month.

Good cold storage practice can show stowage figures of less than 100 cubic feet per ton ; but, on the whole, low figures indicate bad practice. Bad practice can show 90 cubic feet to the ton and even less. In one case, good stowing and making use of every available foot of space, while paying due regard to the necessity for adequate dunnage and ventilation in the stacks, will bring the stowage figure down to less than 100. In another, the figure is brought down by stowing as tightly as possible, with all the rules for safe stowage, separations between stacks, and so on, disregarded.

One hundred cubic feet per ton is a good average figure to use when assessing the storage capacity of a store. It will vary if the proportion of cased to bagged goods alters, and if consignments are received requiring a tremendous number of separations, naturally more space per ton will be occupied. If chambers have too much height, overhead space will be lost because of the impossibility of high stacking. High stacks mean overloading the floors. Average floors will seldom support more than three hundredweight to the square foot, and, as this pressure is generally given by a stack eight feet high, it is not safe to stack higher. Consequently, chambers higher than ten feet (allowing the necessary two feet above the stacks) cannot be stowed to 100 per cent. occupancy.

* See note on p. 180.

The revenue per cubic foot yielded by each chamber should be recorded, and the recorded figures should be annually compared with the known earning capacity of the chamber. Account should also be kept of the operational costs per cubic foot. These are simple enough matters, but, for all that, none the less useful.

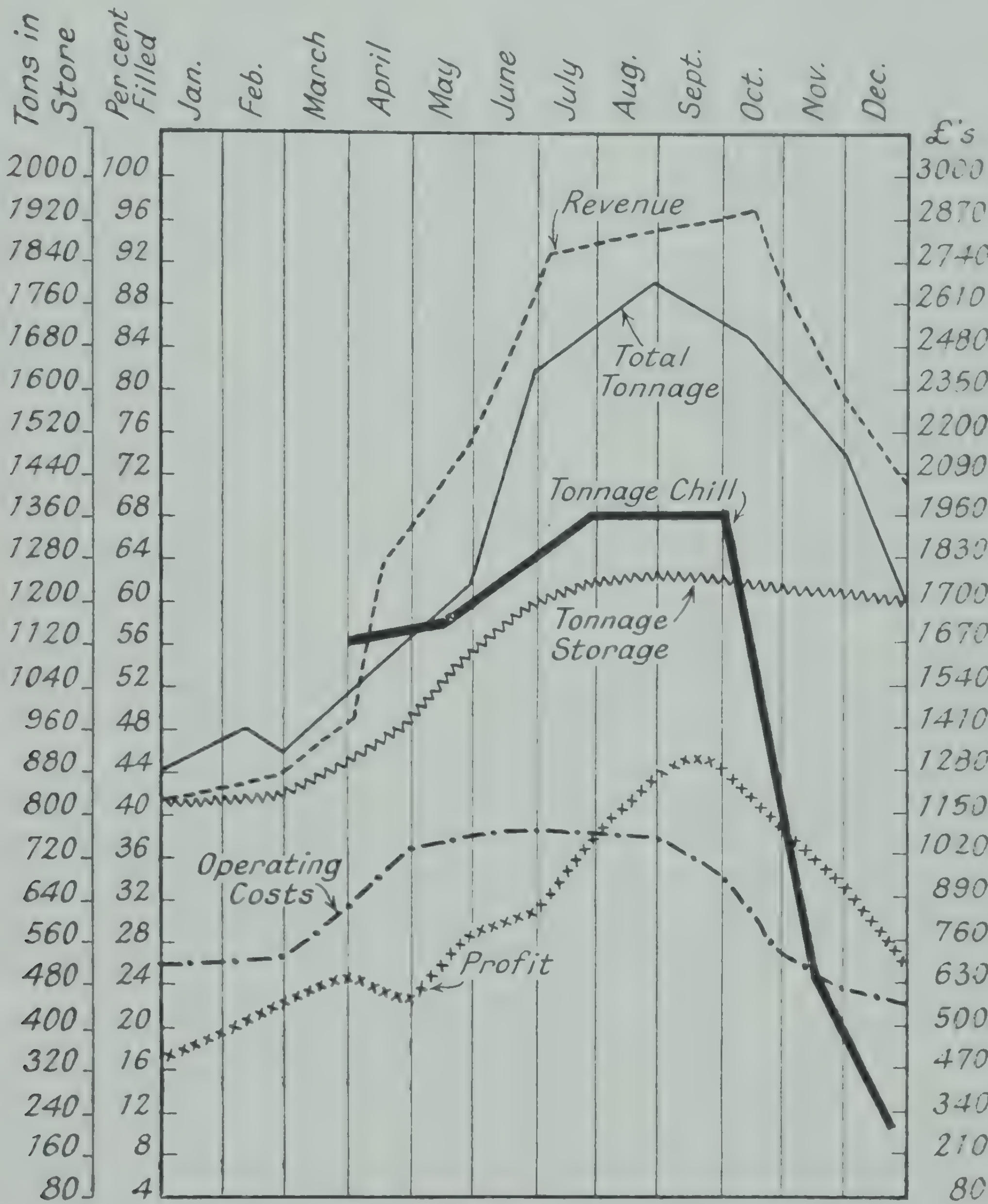


Fig. 39.—Monthly Chart.

More difficult is the calculation involved in estimating the increased operational costs caused by the admittance of particular products. It is not easy to assess the load on the refrigerating plant contributed by, say, two tons of ship's stores consisting of meats, fish, and butter in a semi-frozen state, together with several cases of assorted vegetables and fruits.

Basis of Rates

In the early days of the industry rates for storage rent and handling do not appear to have been calculated. They were probably assessed as a *fair* charge —reasonable in the opinion of those who had to pay. If, at the end of the year, the cold store balance sheet showed a profit, then the rates were deemed satisfactory. If not, a small percentage was added.

When competition came along, rates were cut, and operating costs *somehow* reduced in order to obtain the necessary margin of profit. It is, however, recognised that there is a limit to reduction of operating costs. Cut-throat competitive rates are of little benefit except to the customer of the cold store, and he will not object to paying increased rates if he knows that they are justifiable. Justifiable storage rates must be calculated scientifically. To do this, operating costs must be carefully assessed.

Power consumption and wages are the two main costs in cold store expenditure. Each of these increases with traffic increase, but power cost per ton should decrease as occupancy figures rise.

A record should be kept of the following :—

(1) Revenue per ton handled.
(2) Power consumption per ton movement.
(3) Revenue per ton stored.
(4) Power consumption per ton stored.

Take the months, January to June, and compare (1) and (2) with the same period of the previous year. To find the number of tons stored for (3) and (4), it will be necessary to add together the stock figures for the end of each week and divide the total by the number of weeks in the period.

Any variations revealed between the results for corresponding periods of each year are due to certain causes. Investigation of these causes will indicate points requiring attention—important points that in ordinary cold store routine usually escape attention. It is these points which have an important bearing on the assessment of rates for particular commodities, and to ignore them may prove costly.

Power costs should always be calculated (*a*) per cubic foot capacity, (*b*) per ton goods movement, (*c*) per ton goods stored, and (*d*) per refrigerating tons output.

There are always various obvious reasons for fluctuation in (*a*). Fluctuation in (*b*) will depend upon the traffic in the store, and the variations will indicate what is happening. Variation in (*c*) is a definite indication of thermal losses. Differences in (*d*) can and should be explained by the engineer.

Refrigerating Tonnage Output

R.T.O. is the refrigerating capacity of the compressor multiplied by the compressor running hours. A 30-ton refrigerating compressor running 90 hours in a week shows a refrigerating tonnage output of 270 tons. Possibly during

that week the traffic in and out of store totalled 250 tons. This would give an output of 1·08 refrigerating tons (R.T.O.) per ton goods movement. The following year the same volume of traffic may show that a higher refrigerating tonnage output is necessary. If the occupancy figure, and the atmospheric and other conditions are approximately the same as in the previous year, then the reason for the higher R.T.O. must first be sought in the condition of the plant. If there is no question of decreased plant efficiency, then the necessity for the increased refrigerating tonnage output per ton of goods moved will most probably be due to the condition or nature of the goods received for storage.

The cost of the increased refrigerating load should be included in the rate charged for the storage of the goods making the increase in refrigerating tonnage output necessary.

Take, for example, the effect of the receipt of two or three tons of defrosted oddments for which a storage charge of, say, 56/- per ton per month would normally be made. With a small plant such a receipt may mean an extra hour's running. The cost of this extra running should be met by an additional storage charge, if only to cover the cost of the extra power consumed by a small margin. Yet this is seldom done at present. It would be no exaggeration to say that the rates for storage ruling at most cold stores frequently do not cover operational costs. Occasionally it is revenue derived from incomplete rentals that helps to provide the profit margin. Most storage charges are based on monthly rentals, any part of a month counting as a full month. The quick turnover of certain stocks, therefore, helps to swell the revenue total ; many consignments are received one week and delivered the next, while still incurring a month's charges. If it were not for this, rates would have to be increased.

Weekly rates, even daily rates, have been introduced at certain stores. These rates are, of necessity, higher than monthly rates. Quicker turnover involves increased handling costs. For the same reason, the smaller the package or consignment—under one ton—the higher the rate, simply because of the extra handling involved.

CONDITIONS OF STORAGE

The conditions of receipt or deposit of goods for refrigerated storage are usually printed on the back of each Landing Account or Receipt Note. Conditions are practically the same at every cold store. As will be seen, the Cold Storage Proprietor is legally covered against most possibilities, and goods are received at the owner's risk. Refrigeration and good cold store practice will not ensure against every risk of poor out-turn of commodities after storage ; there are many excellent reasons for conditions of storage to be phrased as they are. Nevertheless, although the Cold Storage Proprietor repudiates liability for damage on principle, the necessity for retaining goodwill may in certain cases impel him to interpret his conditions other than literally.

1. The Company will not be responsible for loss or damage to goods stored occurring through Act of God, War, Civil Commotion, Riot, Looting, Explosion, maintaining too high or too low a temperature in the Chambers, failure of machinery or plant, negligence, fire, vermin, strikes, lock-outs, theft, including theft by the Company's servants, or any other causes whatsoever. In case of fire, storage is payable to the expiration of the current storage month.

2. The Company will always, and at all times, use their utmost endeavours to prevent any damage to, or loss of, goods entrusted to them, and will render all assistance in their power properly to preserve and keep goods consigned to their care and keeping. It is to be understood, however, that all goods are received at Owner's risk, and that any liability will at all times be repudiated by the Company.

3. Goods are received only if subject to a general lien for all charges accrued and accruing against the owner of the goods, or for any other money due, from the owner of the goods, and if such lien is not satisfied after seven days' notice in behalf has been given to the owner, or sent by post to the last known address of the owner, the goods or any part of them may be sold to defray the lien and all expenses incurred.

4. All consignments to the stores must be plainly marked with the owner's name and address, and the date.

5. Transfers are allowed subject to a general lien on the goods transferred for all sums due from the persons, or person, who occupy or have occupied the position of owner, whether at or before the date of such transfer.

6. No goods will be given up without production of satisfactory proof of ownership, or satisfactory proof that the person demanding delivery of the goods is an authorised representative of the Owner or Owners.

7. The Company will not be answerable for any delay, loss or damage arising from labour disputes, or circumstances either within or beyond their control, nor for any consequences therefrom, whether due or not due to the conduct of the employees of the Company, or to the conduct of other employees.

8. The Company reserve to themselves the right to refuse any goods that in their opinion are unfit to store. The Company have the right to remove from their premises, if necessary without notice, any goods found to be of an offensive nature, or such as will damage other goods in the store, and shall not be responsible for any damage occasioned by such removal. The Company have the right to open any package, sealed or otherwise, held in store, if an examination of its contents is deemed necessary.

9. The Company reserve the right to make such changes in their charges for storage on goods stored or to be stored as they deem fit, by giving three days' notice to the owner of such intention to change charges.

10. It is understood that charges for rent commence on the day of application for space whether goods are in store or not, and terminate at the end of the current month during which goods are removed from store.

11. Accounts are payable monthly. Cash storage goods must be paid for before delivery is made.

(*N.B.*—In some stores, cash storage is payable before goods are accepted. One week's rent is the usual charge as deposit, the balance to be paid on delivery if the rent is for more than one week.)

12. Charges are computed on marked weights and numbers of all goods. Where marked weight is in doubt, goods are weighed in on the Company's scale. A separate charge is made for such weighing. Weights in all cases are gross weights.

RATES

While rate charges tend to follow a standard form, there are certain variations in different areas according to the different class of business transacted. The actual prices vary a little. Inland, they are slightly lower than at cold stores situated in ports or at towns in the coastal areas. This is because wages are less inland than those prevailing at the ports.

All rates are based on gross weights unless otherwise quoted.

Where neither weight, nor package is quoted, the rate is to be presumed per gross ton stored.

Goods for Storage Temperature of 14-16°

Bacon in Bales or Boxes—per ton . . . First week 19/6, then 9/8 per week.

	Monthly (28 days)	
Frozen eggs—per ton	32/3	Then 7/3 per week
Butter—per ton	32/3	,, 7/3 ,,
Frozen Beef, Sheep, Lambs, Pigs, Rabbits, Offals, etc., in bags or cases or cartons—per ton	32/3	,, 7/4 ,,
Beef, or other meats in defrosted condition for freezing—per ton	55/-	,, 7/4 ,,
Freshly killed meat for chilling and freezing—per ton	71/-	,, 7/4 ,,
Ships' Stores and/or Miscellaneous Parcels—per ton	71/-	,, 10/2 ,,
Poultry, Frozen—per ton	33/4	,, 8/1 ,,
Poultry, Fresh for Freezing—per ton	71/-	,, 8/1 ,,
Fish, Frozen—per ton	41/-	,, 9/4 ,,
Fish, Fresh for Freezing—per ton	71/-	,, 8/1 ,,
Pickled Meats in casks—per ton	45/2	,, 9/8 ,,

Meats, etc.—Package Rate—

Per Quarter	2/5 per week or portion.
Up to and including 28 lb.	1/2 ,, ,, ,,
Over 28 lb. and up to 56 lb.	1/6 ,, ,, ,,
Over 56 lb. and up to 112 lb.	2/5 ,, ,, ,,
Over 1 cwt. and up to 2 cwt.	3/3 ,, ,, ,,
Over 2 cwt. and up to 3 cwt.	4/- ,, ,, ,,
Over 3 cwt. and up to 4 cwt.	4/10 ,, ,, ,,
Over 4 cwt. and up to 6 cwt.	6/11 ,, ,, ,,

Bullocks' Heads and Livers	4½d. each first week, 2½d. per week thereafter.
Plucks, etc.	4½d. each first week, 2½d. per week thereafter.

Goods for Chilling

Shell Eggs—Quarter case	10¼d. per month.	3d. per week.
,, ,, —Half case	1/8½ ,,	5d. ,,
,, ,, —Long case	3/4 ,,	10¼d. ,,
Bacon—per ton	42/- ,,	7/6 ,,
Margarine—per ton	37/7 ,,	7/6 ,,
Lard, Yeast—per ton	37/7 ,,	7/6 ,,
Cheese in crates—per ton	37/7 ,,	8/4 ,,
Vegetables and Fruits—per ton	37/7 ,,	8/4 ,,
,, ,, ,, —Package Rate	As for Storage.	
Wet Fish for Chilling—per ton	52/- per month.	9/- per week.
,, ,, ,, ,, —Packages, ½ cwt.	2/3 ,,	6d. ,,
,, ,, ,, ,, —Packages, 1 cwt.	3/9 ,,	10½d. ,,
Flowers	6d. per box per week or portion (boxes of 2 feet by 12 inches).	

Note.—Vegetables and Fruits—Small Package Rate :—

Up to 10 lb.	2d. per week or part.
Up to 20 lb.	4d. ,, ,,
Up to 30 lb.	6d. ,, ,,

Renting of Space

Special rates are usually quoted for renting space. The smaller the space, the higher the rate. From 6d. to 9d. per cubic foot is the usual rate, but space is usually taken either by renting the whole chamber, or by dividing the chamber into lockers.

Lockers are easily made to suit clients' requirements. Expanded metal frames form the sides of the locker space, the front forms the door, also expanded metal sheets in a wood frame. The locker capacity is seldom less than 250 cubic feet. The doors are locked, and the key is given to the client. Only the representative of the client has access to the locker. The responsibility of the cold store proprietor is limited to supplying and maintaining temperature. By offering locker facilities the cold store proprietor economises on labour handling costs, and obviates the responsibilities and worries of stock keeping. A chamber of 10,000 cubic feet would, with full occupancy, hold 100 tons. An all year round conservative estimate, however, would be calculated on a 40 per cent. occupancy, so that at 30/- per ton per month, the revenue of the chamber for the year could be figured at approximately £780. The proportions of a 10,000 cubic feet chamber would probably be such as to make it about 33 feet square by 9 feet high. Eleven lockers of approximately 500 cubic feet could be erected in this chamber, each at a rental of £6 monthly. This would bring in a yearly revenue of £792.

Charges for Extra Labour, Labelling, Etc.

All charges are based on Gross Weights

Nature of Service	Rate per Ton.
Unpiling, Weighing singly, labelling and repiling	10/2
Unpiling, sorting for delivery of special lots, and repiling remainder	8/-
Loading into lorries and rail vans	9/8
Weighing into Store	4/3
Weighing from Stow and Restowing	9/8
Turning over and taking Marked Weights	9/8
Taking marked weights on Receipt or Delivery	3/-
Weighing meats on delivery in less quantity than five bags or carcases	5/3
Weighing contents or counting contents of bags or cases	10/-
Test weighing Cases and/or Bags	9/-
Survey and Inspection	10/-
Reconditioning of Meats	Actual labour cost plus 70 %.
Cutting Beef :—	
1st Cut	8d. per quarter.
Other Cuts	2¼d. each.
Sheep, Lambs, etc.	3d. each cut.
Splitting Pigs,	7d. each.
,, Lambs, Sheep	6d. each.
Bagging Beef	3d. per quarter.
,, Sheep, Lambs	1/6 per doz.
Supplying certified weights	3/2 shipment.
Working out of normal hours	Actual Wages plus 70 %.
Labelling	2d. per label.
Coopering	Actual cost plus 70 %.

OTHER REVENUE

Other sources of revenue, apart from rates for storage and renting of insulated space, and for various operational services, are mainly connected with composite business interests, and are distinct from general cold store warehousing. There is, however, one source of revenue, directly connected with cold storage practice, that should be mentioned here : loaning money. This is a feature of the cold storage business frequently met with abroad ; and in some areas of this country also it has become the principal part of cold storage business, and is a growing practice. Loaning money on goods stored in cold chambers is, of course, attended with a certain amount of risk. Loaning money is the business of the banks. Banks require security. Cold stores are asked to loan money usually where the security is doubtful. Cold store proprietors rely on their knowledge of cold store products, and their personal knowledge of the borrower's integrity and business ability. Eggs, butter,

cheese, and often poultry, are the main products considered, but more money is loaned on shell eggs than on any other goods.

The prices of cold store products are seldom stable. Particularly is this the case with eggs. Eggs, for this reason, attract the small man. In March, he will want to buy eggs in order to have stocks against the high prices ruling from the following October when eggs are scarce. He will have experience, judgment, sound connections with dealers, a good reputation, but no money. He will approach the cold store proprietor who will advance him money to buy the eggs.

The cold store proprietor thus ensures for himself nine months' occupancy of his chambers, nine months' storage revenue, and nine months' interest on the money he has advanced. His security is the value of the eggs in store.

The general rule is to limit the loan to 60 per cent. of the total value of the goods stored. The interest rate varies but averages round about 7 per cent. The agreement between the cold storage proprietor and the borrower is so phrased that the borrower binds himself to

(1) Pay storage charges monthly in advance.
(2) Pay monthly a proportion of the borrowed capital.
(3) Pay monthly interest on the whole of the loan.
(4) Pay monthly the additional charge on any arrears.
(5) Agree to a reasonable margin being allowed on the loan should the commodity price drop.
(6) Agree to pay immediately any difference between the total value of the goods stored and the original agreed 60 per cent. loan value.
(7) Before any goods can be withdrawn from store all arrears of interest, storage, and other charges to be paid up.
(8) While withdrawals are being made, the total value of remaining stock never to fall below the balance of loan value to be repaid.

Notwithstanding all the above provisions designed to safeguard the cold store proprietor, the risk remains high. Loaning of money, therefore, should never be made unless the proprietor is fully experienced, and has an extensive personal knowledge of the borrower.

Note.—The average stowage figure of a store, expressed in cubic feet to the ton, will vary with the proportions of the different classes of commodity stored. A 1,000 ton store filled with, say, 500 tons of meats, 300 tons of bacon, and 200 tons of butter, will have a different average stowage figure from a 1,000 ton store filled with 500 tons of butter, 300 tons of meats, and 200 tons of bacon. In this book, generally speaking, the convenient round figure of 100 cubic feet to the ton is used to indicate fairly tight stowage, but the figure of 130 cubic feet to the ton is a more correct assessment.

CHAPTER 22

ACCOUNTS—STORES SYSTEMS—RECORDS

SIMPLICITY AND ELABORATION

THE reputation of a cold store and the efficiency of its organisation depends mainly on its good name for invariably correct deliveries. The more simple a store's account system, the more is efficiency to be expected. The tendency nowadays is for more and more elaboration. Elaboration is a natural result of attempts to make accounts watertight, but very often the expense of making an account system watertight exceeds the losses which may occur from theft and fraud.

Nevertheless, systems must be watertight, and this quality should be combined with simplicity, efficiency, and as little duplication of work as possible. Elaboration usually involves duplication. Duplication necessitates double checking.

Stores' accounts systems should embrace correct postings, correct records of intakes, correct entries of deliveries, and correct charges. The system should include methods of cross checking. Detection of errors should be made easy.

Some stores favour card systems. The main advantage of the card system in comparison with bound ledgers is that dead matter is easily transferable. There is automatic self-indexing, and new ledgers are not necessary.

The serious disadvantage of cards is that they can be misfiled and time wasted looking for them. Often a card is lost altogether.

The permanent bound ledger, however, has so many disadvantages that the card system is easily the more efficient. By way of compromise, the loose leaf ledger is rapidly becoming universally popular, and methods for binding loose leaves are being improved every year. Index sheets with projecting tabs that are always visible are used to divide the main sections contained in the one binding. Indexing can be done in alphabetical, numerical, or geographical order, or simply in the usual order of classified commodities.

Necessary for any cold stores are main ledgers for main stocks, and small subject stock ledgers from which deliveries can be made. These ledgers show the date of receipt of goods, a full description and the quantity of the goods received, details of the account against which the goods are entered, and details of deliveries made showing date and quantity.

A summary book is needed to show daily receipts and deliveries, and a tonnage book to record the total tonnage of the stock and preferably to show the weekly position. It is better for it also to show the volume in cubic feet occupied by each item and against whose account it is stored.

In addition, an account ledger showing rent and storage charges against respective customers will be required. Invoice and statement books, cash and

DATE	DAILY SUMMARY	FREEZER			CHILL MEATS						CHILL SUNDRIES			STORAGE								
		FISH	MEAT	SUN-DRIES	QTRS.	SHEEP	LAMBS	PIGS	OFFAL	CALVES	EGGS	FRUIT	LIQUID	BEEF	LAMB	PORK	BACON BALES	BACON BOXES	BUTTER	FISH	OFFAL	OTHER
	RECEIVED																					
	DELIVERED																					
	REHANDLED																					
	TOTAL																					

DATE	DAILY REPORT	TONS RECD.			TONS DELD.		CHILL				FREEZER				STORAGE				TOTAL			HDLD.	NO. OF MEN	TONS P.M. P.HR.
		EX RAIL	EX ROAD	RE HLD.	TO RAIL	TO ROAD	RECD.	DLD.	HDLD.	IN STORE	RECD.	DLD.	HDLD.	IN STORE	RECD.	DLD.	HDLD.	IN STORE	RECD.	DLD.	IN STORE			
	BT. FRD.																							
	TOTAL FOR WEEK																							

Fig. 40.—Headings for Daily Report and Summary Books.

receipt books, day book and so on, will follow the usual description. The books for wages, salaries, consumable stores, and all those necessary for dealing with operating costs and expenses, will vary little from the books kept in most industries for similar purposes.

The important books are the stock books ; and the system adopted for checking receipts and book deliveries is peculiar to the cold storage industry. Most cold stores adopt the same procedure. Any variations are usually because of local differences in the commodities stored, and in the methods of handling.

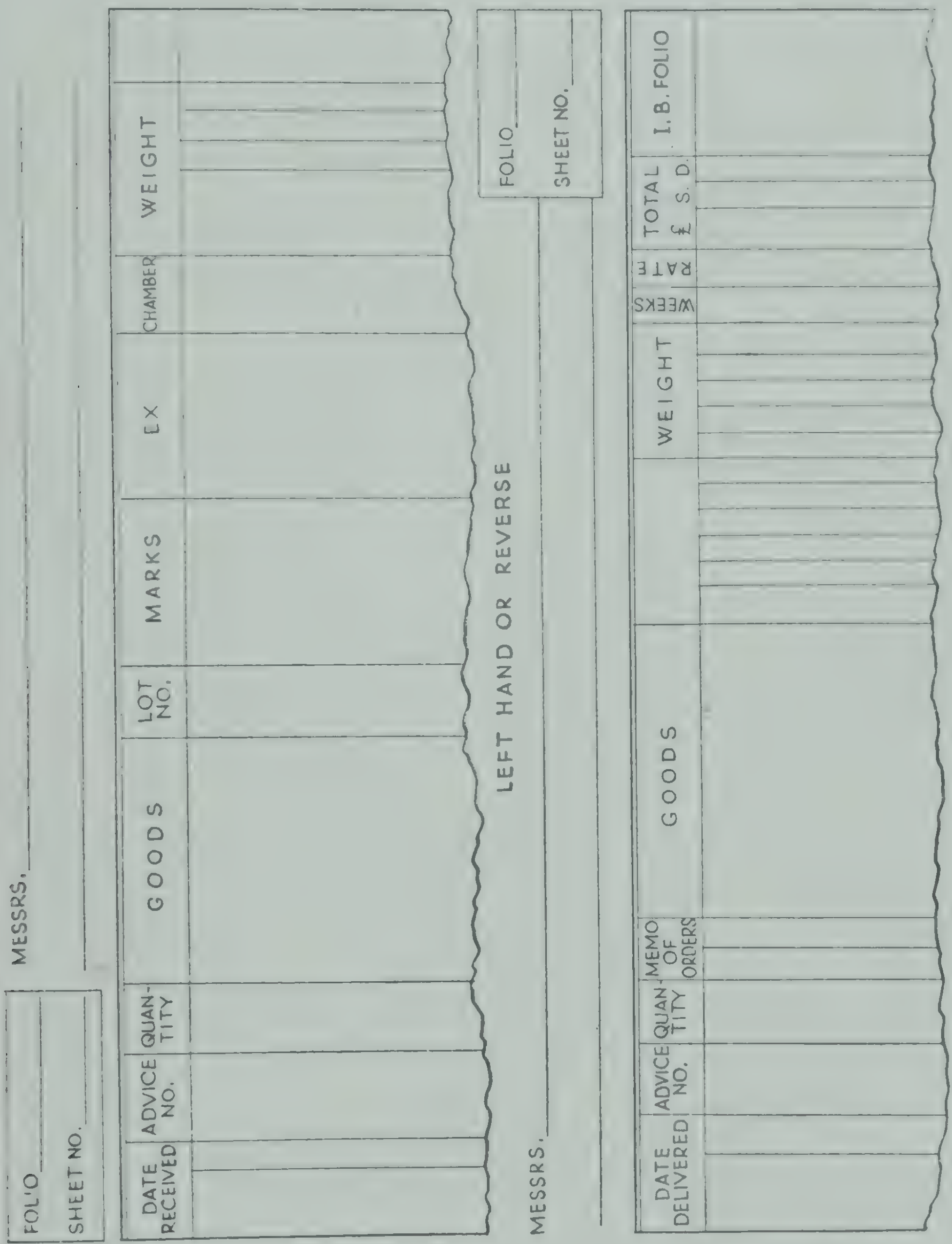


Fig. 41.—Stock Book Sheet (Front and Reverse).

An outline of the cycle of receipt and delivery booking was given in the notes on Checking. The same cycle is adopted for credit and cash customers depositing goods for storage. Naturally, different books and forms are used, and with cash customer trade there is less clerical work.

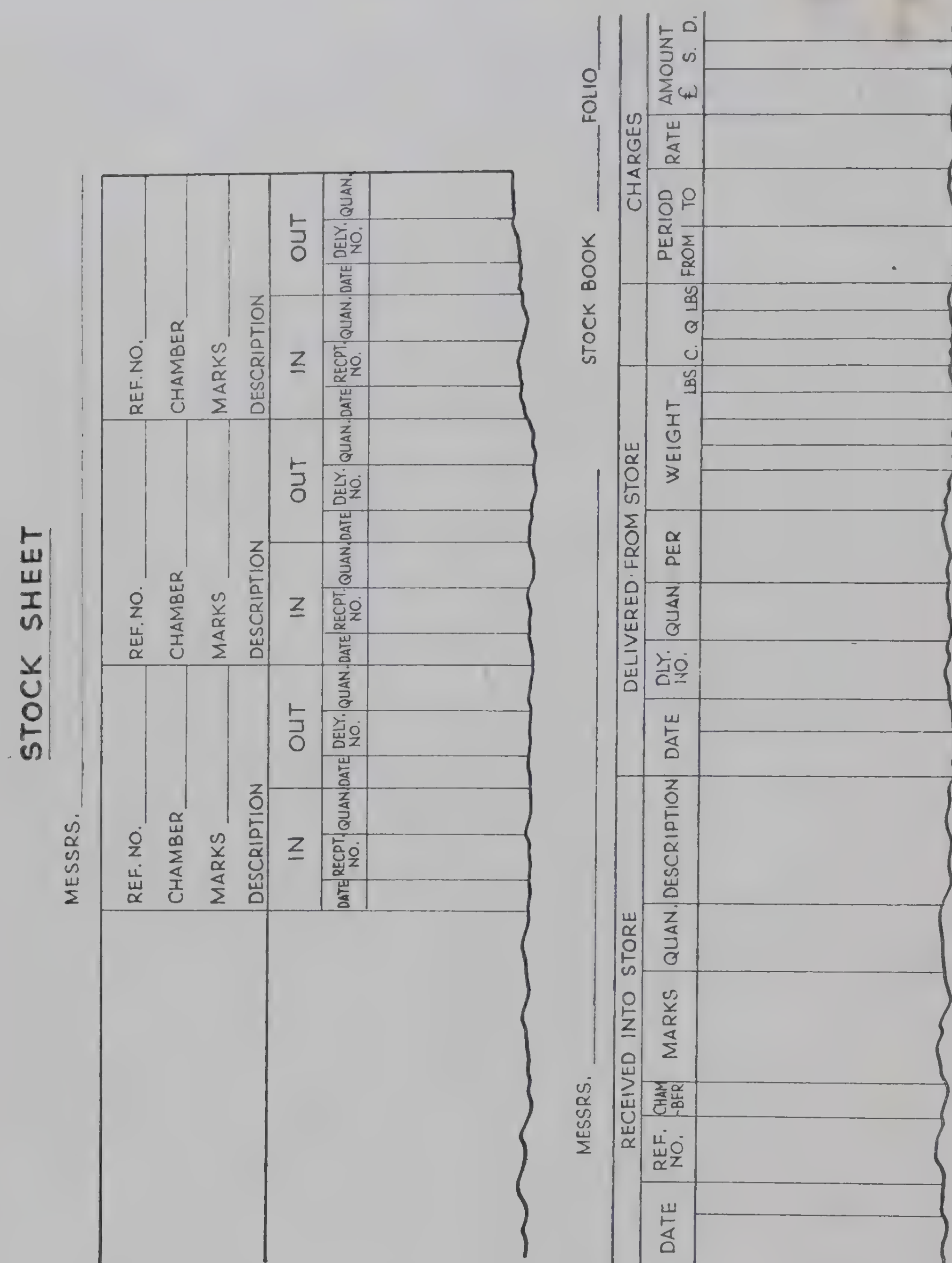


Fig. 42.—Another Specimen of Stock Book Sheet.

The different operations in a cold store office are separate and distinct. They can be classified as :—

(1) Counter work. Attending to the booking in of vehicles with goods for deposit, and attending to vehicles calling for delivery of goods.
(2) Posting of receipts and deliveries in Stock books.
(3) Advising of goods received and delivered.
(4) Daily summary and totalling of traffic in and out of stores.
(5) Accounts. Collation of rent charges.

OFFICE PERSONNEL

The number required to make up a complete office staff depends, of course, on the capacity of the store. Large or small stores follow the same procedure in the clerical work necessary for the storage of goods. Each one of the five steps outlined above must be carried out. Where cold stores differ in their routine is in the number of vehicles handled for deliveries. Deliveries in bulk involve little clerical work, but small deliveries can mean a tremendous number of individual advices, and postings. Receipts in some stores, particularly market stores, can be as many as forty to the ton, whereas other stores may handle 300 tons as one receipt only.

Deliveries are seldom made in bulk. Even stores of large capacities handling heavy intakes usually make deliveries piecemeal. Many stores act as distributing agents, arrange transport, retail collection, and so on. The reception of 100 tons of goods usually involves 12 to 25 road vehicles. Delivery of the same 100 tons invariably necessitates a greater number of vehicles, and often as many as two or three times the number used for intake.

The driver of each vehicle bringing goods to the cold store will present himself at the office window. There, the counter clerk will obtain from him the number of the vehicle, the quantity and nature of the goods, the port or town of despatch, the name of the consignee, the number of shipment, and so on. These the clerk will enter, together with the time, in the Intakes Book. He will then instruct the driver where to take his vehicle.

When the vehicle is unloaded, the driver will again call at the office window to hand in the checker's receipt note bearing the checker's signature. The counter clerk will check this with the entry in the Intakes Book, note the differences, if any, enter the time the vehicle was cleared, and make out a clearance note, which he will hand to the driver.

The driver of each vehicle calling to collect goods will present a note of authority to the counter clerk. The clerk will check this in the small counter stock book. He will have to ascertain : (i) whether there are any goods in the store in the name of the authority asking for delivery ; (ii) whether the goods are of the same description as quoted by the authority ; (iii) the balance which remains in store and whether the whole of it, or only part of it, is now being collected ; or, as very often happens, whether the demand is for more than the balance ; (iv) he must satisfy himself that rent charges have been met, and that there are no special instructions with regard to the account that must be complied with before deliveries are made.

If everything is in order, the counter clerk must book in the Deliveries Book, the number and name of vehicle, the time it arrived, and the particulars of the goods asked for. He must then make out a Delivery Order to the stores foreman, quoting all particulars so that there will be no possibility of making a wrong delivery. He will hand this to the driver, and give him instructions for finding the foreman, and for taking his vehicle to the right place. He must then file the authority for the delivery presented by the driver.

When the delivery has been loaded on to the vehicle, the driver will again present himself at the window. The checker's notes giving details of the weights, etc., of the delivery will be checked by the counter clerk. The clerk will make out official delivery advices, usually in quadruplicate, which the driver will sign. He will be handed a copy, and this will serve as his pass out.

The work of the counter clerk is now finished—until the arrival of the next vehicle. He will initial the receipt and delivery notes and pass them over to the stock clerk.

If the cold store is fairly large the stock clerk will be another person. In many cases, however, the counter clerk, stock clerk, advice clerk, summary clerk are all one and the same person.

The stock clerk will post the details of both receipt and delivery into the main stock book, and then pass the checker's receipt and delivery notes to the advice clerk.

These notes will be stamped and initialled by each clerk as each step is completed. Thus, the stock clerk will not make any postings unless the notes have been initialled by the counter clerk to show that they have been checked. The advice clerk will not prepare any advices unless the notes bear the initials of the stock clerk to show that the entries in the main stock books have been posted. The summary clerk will not include in his daily summary any notes, either receipt or delivery, unless they bear initials showing that checking, posting, and advising have been completed. The filing clerk will look for the initials of the summary clerk before filing any papers dealing with receipts and/or deliveries.

The counter clerk will keep all papers dealing with receipts and deliveries separate for each vehicle until he passes them on to the stock clerk. They will be kept separate and in order until they reach the filing clerk. Receipts, for example, will begin with a transport note or carter's consignment note. To this may be added an advice of the booking of this consignment for the store, possibly a letter or telegram or both. The checker's note will follow. These will be pinned together and pass to the stock clerk's desk. The advice clerk will add a copy of his official advice or landing account, and then the summary clerk may add a sheet of paper showing his calculations in preparing his summary of the tonnages, etc. The filing clerk will clip all these papers together, and in front on a slip of paper, mark the reference code so that reference in the future, if necessary, will be easy.

Deliveries will be built up in the same way. The counter clerk begins with the authority presented by the driver of the vehicle making the collection. The checker's note will be added, then the delivery advice copy bearing the signature of the collector.

Filing must be done daily, otherwise there is a build-up, and very soon, chaos. Telephonic enquiries about receipts and deliveries can be numerous. Immediate replies are necessary, and quick, easy reference to receipt and delivery notes must be possible.

CREDIT AND CASH CUSTOMERS

So far we have dealt with goods received for storage for customers with credit accounts. In the majority of cold stores, and particularly, in stores connected with markets and abattoirs, there can be a considerable cash storage business.

Such business is sufficiently lucrative to make it worth while, but the quantity of each individual transaction is so small that a system of booking is required that involves as little clerical work as possible.

The checker on receiving a case, bag, or piece for storage will make out a ticket of receipt in triplicate. Each one will be a different colour, say, green, red, and buff. The green one showing the date, quantity and description of the goods is the receipt note and is given to the owner. The red one is pinned, tacked, or pasted on to the article or item going into the chamber. The buff one is taken to the office and given to the counter clerk.

All three tickets bear the same number, and the checker having written the details of the receipt on the original through carbons, the duplicate and triplicate show the same particulars. When the owner of the goods presents his receipt for delivery, the counter clerk will exchange the green receipt note for the buff coloured copy. He will not make this exchange, however, until the owner has paid the fee for storage. The fee will be estimated by the counter clerk from the particulars on the ticket. The date of entry into store and the quantity are the only details he requires to fix the rate. The counter clerk will make out a receipt for the money received. With the money receipt and the buff coloured ticket the owner can then go to the checker who has instructions not to issue goods to persons without them.

No further clerical work is required, with the exception, of course, of checking cash received against receipts made out.

RECAPITULATION OF CYCLE

Receipts

Goods received ex rail, vehicle, or porter, are first booked in at the office by the counter clerk, unloaded by storemen, and checked by the store checker, who takes full details in a numbered, duplicate receiving book. The checker will sign the carter's consignment note, and duplicates of the consignment note and the checker's receiving note (showing full details of goods received, condition of goods, number of chamber in which they are stowed, and time stowing was completed) are handed in to the office.

These are then checked by the stock clerk, and entered in the stock book. Official receipt notes or landing accounts are made out, and copies are posted to consignees or owners. The summary clerk collects all receipt notes, checks and summarises the day's receipts into numbers, descriptions, and weights.

Goods for cash customers are received on tickets ; the original is handed to the customer, a duplicate is attached to the goods, and a triplicate is kept

in the office in numerical order. The summary clerk checks through these at the end of the day, and includes them in his summary.

When deliveries are requested, cash customers simply present their receipt ticket which is exchanged for the office copy and payment is made. Credit

NORTH HAVEN COLD STORAGE CO. LTD.

PHONE 327

194

MESSRS.

DR.

A/C NO.

S.B. NO.

FOLIO

FROM	TO	QTY.	GOODS	MARKS	EX	WEIGHT	WEEKS	RATE	£	S.	D.

CERTIFIED

MANAGER

DATE

Fig. 43.—Statement of Account.

customers asking for delivery are expected to send a letter which will serve as an authority and to quote the reference number of the receipt note or landing account issued by the store. The counter clerk checks main stock book items against this reference number and then issues an official delivery order to the foreman or checker. This official delivery order is numbered, and the number is posted in the main stock book.

The checker completes details of the delivery, showing the number and weight and the description of the goods in his own delivery book in duplicate. This, together with the official delivery order from the office, is brought back to the office and the carter signs for the goods. Official typed delivery advices —usually four copies—are made out, and the necessary copies posted to the owner or depot. Details of the delivery are posted in the main stock books, and the summary clerk collects all the day's delivery notes and advices and prepares his summary in numbers and tonnages.

The day's receipts and deliveries for each vehicle are then filed.

When a consignment for either a credit or a cash customer is finally and completely delivered, the receipt notes are stamped with a rubber stamp, "CLEARED."

Rents and Charges

Invoices and statements are sent out at the end of each month. The accounts clerk will make these out from the Stock and Accounts ledger. Charges for overtime, labelling, and such extra services as are usual in any cold store are made up from items entered in the Sundry Charges book. The data for these items are extracted from the delivery and receipt notes made out by the checkers, but it is a good plan, and is customary in most cold stores, for checkers to make out special notes giving full particulars of extra services. From these, the accounts clerk can make out his invoices at the end of the month.

Complete co-ordination between office and loading bank or store is necessary at all times. Repeated checking and cross checking is advisable, and inter-change of the various work and office procedure among the clerical staff is usually a good practice.

LARGE AND SMALL STORES

In some stores one or, at most, two clerks will handle all the clerical work. In others, there will be a clerk for each step of the work. Depending upon the volume of traffic and the number of vehicles involved, the work in the office will fluctuate. In large stores the work will be divided, the store office handling the work of the counter and advice clerks, the town or main office controlling the actual stock-keeping and rendering accounts. In other stores, the work of the counter clerk is done in what is known as the bank office, which is, in other words, a hut on the loading bank. The store superintendent, checkers, and counter clerk are thus together and the daily store routine can be followed through with easy communication, and without disturbing the main office where the work of stock-keeping, accounts, and any subsidiary business in which the cold store may be engaged is carried on. The work of attending to the requirements of lorry drivers can be a noisy business, and it is always advisable to keep this well away from the main office, if possible.

The minimum staff of a cold store office cannot be less than three—the manager, the clerk, and a boy. A cold store with an average daily movement of 75 tons of both intakes and deliveries will require a chief clerk, three general clerks, and a boy. Office routine in a cold store is such that to-day's work cannot be left until to-morrow. Current work must be completed on time. The ideal to be aimed at is to have each movement of traffic completed before the next one is started. This, of course, is seldom possible, but all postings of receipts and deliveries, and all advices must be completed at the end of each day, so that the next day's work can be started clear and without arrears.

WAGES AND BONUS

Wages are usually a weekly matter, but where casual wages are paid, payment must be made daily. Time cards should, of course, be checked daily. Overtime is usually plentiful in a cold store, and the calculation of overtime rates can frequently involve a great deal of work. Few cold stores, however, find it necessary to employ a clerk exclusively for wages. This work can be allied with several of the other jobs that must be done in a cold store office, and that are quite apart from the work in connection with the movement of traffic.

In many stores a bonus is paid to the warehousemen on speed of handling. The object of any bonus scheme is to provide an incentive so that a higher handling speed, measured in tons per man hour, can be attained. No matter how fast the handling may be at any store, it can usually be increased. Such an increase cannot be effected without an inducement, and this will produce better results if in monetary form.

It can be said that the management benefit from a bonus scheme in that faster working reduces operating costs. A reduction in thermal losses is effected because of reduced door opening, etc.

Many bonus schemes are existent. Some are impractical owing to their over-elaboration. The more simple a scheme, the more it is appreciated and understood by the storemen.

Any scheme to be successful should be simple and elastic ; it should involve as little clerical work as possible, and be of such a nature that it cannot be abused. The three schemes in most general use are based on :—

(1) A points system.
(2) A definite rate per ton.
(3) A differential or varying payment for each decimal point speed increase, with allowance for standing by or waiting time.

The disadvantages of the first two are that :—

(1) A points scheme is too elaborate, and involves too much clerical work ; and (2) a definite rate per ton involves considerable clerical work and in small stores with composite businesses, becomes rather complicated.

(3) A differential rate scheme is simple. It is, however, loose, in that the calculation of the standing-by time can favour either the men or the employer. To guard against such looseness it is necessary for the manager, or some other competent person, to have the full responsibility for calculating and awarding the standing-by time.

Briefly, scheme (3) is as follows:—

A minimum of four tons per man per day of eight hours must be worked before any bonus will be awarded.

Assuming the staff of a store to number 12 men, to work 8 hours, and to handle 70 tons; then,

$$\text{Speed per hour} = \frac{70}{8} = 8{\cdot}75 \text{ tons.}$$

$$\text{Speed per hour per man} = \frac{8{\cdot}75}{12} = 0{\cdot}75 \text{ ton.}$$

$$\text{Or, say, } \tfrac{7}{10} \text{ ton.}$$

This is $\frac{2}{10}$ ton over the minimum working speed of $\frac{5}{10}$ ton. Payment of bonus is one penny per ton for each tenth ton over the minimum.

Therefore, payment equals $70 \times 2\text{d.} = 140\text{d.} = 11/8$,

$$\text{or, } \frac{11/8}{12} = 1/\text{- per man, approximately.}$$

On days when tonnage movement is low, or when men are awaiting transport before they can commence work, the manager should allow standing-by time, and bonus statement would be as follows:—

No. of tons handled	65 tons.
No. of hours actually worked	6·5 hours.
Standing-by time	1·5 hours.
No. of men	11 men.
Speed per hour—6·5 ÷ 65 = ...	10 tons.
Speed per man—10 ÷ 11 = ... ∴	$\frac{9}{10}$ ton.
Payment per ton	4d.
Payment per man—65 × 4 ÷ 11 = ...	2/-

For checkers, or personnel only partly engaged in handling tonnage, half bonus payment is made.

In some stores, an increasing payment is made for each additional tenth ton increase in handling speed.

Up to $\frac{5}{10}$ ton speed per man per hour	.. ..	Nil.
,, $\frac{6}{10}$,, ,, ,, ,,	.. ..	1d.
,, $\frac{7}{10}$,, ,, ,, ,,	.. ..	2d.
,, $\frac{8}{10}$,, ,, ,, ,,	.. ..	3d.
,, $\frac{9}{10}$,, ,, ,, ,,	.. ..	4d.
,, $\frac{10}{10}$,, ,, ,, ,,	.. ..	6d.

RECORDS

Records are necessary in any business. Without records there cannot be a true picture of what is happening. The cold storage business is such that accounts must be accurate and clear. The picture presented must be comprehended at a glance. Analysis must be easy.

Before considering the final picture in its entirety, it will be advisable to list the usual necessary initial records. Such records are apart from the customary books and ledgers from which the accounts are made up.

There are three principal departments in a cold store, the deck or store, the engine room, and the administrative office. Where the business of a cold store is plain, straightforward cold storage warehousing, these three departments can be kept separate, and costs and data in respect of each can be built up without difficulty. Where the business is of a composite nature, and deck or stores staff are employed on both or all phases of the business, the separation of costs and analysing of data, particularly with engine room and refrigerating plant records, becomes more complicated.

It is, however, with the latter that the value of internal records becomes more apparent. It is not too sweeping a statement to say that few cold stores can bear analysis without a revelation of inefficiency, but, frequently, managements are blissfully unaware of the fact. Yet this inefficiency and its cause would be instantly revealed if adequate records of the relevant data were kept.

A monthly statement and an annual balance sheet is not sufficient for any cold storage business, large or small, straight or composite. A monthly analysis as complete as it possibly can be is always necessary. Such an analysis does not entail a great deal of work ; if based on the column headings shown in Fig. 44 it can be produced in an hour and a half, provided the internal records of each department have been maintained daily.

An analysis based on this particular plan provides information so complete that practically every question relative to refrigerating plant and cold storage practice can be answered without any further reference to books or accounts.

The usual necessary internal records are as follow :—

1. Allocation—Intakes or Forwardings Book.
2. Intakes Book.
3. Deliveries.
4. Stowage or Chamber Details.
5. Time Book.
6. Wages Book or Sheets.
7. Bonus Payments.
8. Equipment Book.
9. Engine Room Log Book.
10. Consumable Stores.
11. Defect Book.
12. Summary or Tonnage Book.

ANALYSIS

	1	2	3	4	5	6	7	8	9	10	11	12
MONTH	E.R. Costs Total	E.R. Costs Per Cu. Ft.	E.R. Costs per T.G.M.	Deck Costs Total	Deck Costs per Cu. Ft.	Deck Costs per T.G.M.	Admin. Costs Total	Admin. Costs per Cu. Ft.	Admin. Costs per T.G.M.	Total Revenue All Sources	Total Profit or Loss	Total Costs per Cu. F
JANUARY												
FEBRUARY												
ETC.												

13	14	15	16	17	18	19	20	21	22	23	24	25
Total Costs per T.G.M.	Total Revenue per Cu. Ft.	Total Revenue per T.G.M.	Total Profit or Loss per Cu. Ft.	Total Profit or Loss per T.G.M.	Total Loss on Space not Occupied based on Rev.	Total Costs on Previous Year Plus or Minus	Total Revenue on Previous Year Plus or Minus	Total Profit or Loss on Year	Prog. Total Profit or Loss	Prog. Total Profit or Loss per Cu. Ft.	Prog. Total Revenue per Cu. Ft.	Prog. Total Costs per Cu. Ft.

Fig. 44.

Form of Records

Most of these books can be ordinary foolscap books, ruled with feint lines, and with stiff covers ; they can be bought at any stationer's. A few will need to be printed such as wages, time, and engine room log sheets. Others can be loose-leaf sectionised books of the ledger type.

Allocation Book

This is simply a list of all advices and bookings of space. Column headings provide for date of booking, reference number, tons or numbers of cases or bags or pieces, description, and port of despatch. A wide column leaves room for remarks, actual quantity received and date, etc. In estimating space available, this book shows at a glance, space already allocated but not yet filled.

Intakes Book

This shows particulars of each individual consignment. The total quantity received, the number of vehicles employed, the date of receipt of each, remarks on condition, etc.

Deliveries Book

This shows a summary of all delivery advices for each consignment received as per the Intake Book. The total quantity delivered, the number of vehicles employed, the dates, and so on, with remarks on out-turn.

Storage or Chamber Details

This shows the movement in and out of each chamber, with details and description of the commodities stored therein. No estimate of the revenue earned by any particular chamber can be made without reference to the chamber book.

Time Book

Time keeping systems are many and varied. There is little need to enlarge on the use of time cards, clocks, or time books. The same applies to Wages Sheets, and Bonus Payment Books.

Equipment Book

The equipment of a cold store must be kept up to standard. The equipment of each department should be listed in separate sections. This book can easily be combined with the Defect Book. The columns should show date received, description of items, supplier, cost, amount or number required, amount or number consumed or used, balance on hand, and total cost.

Defect Book

The importance of this book, sometimes known as the General Maintenance Book, was stressed in the section on maintenance work. It should be loose leaf

and sectionally arranged. It should contain full particulars of every item of plant and equipment. Date, cause, and cost of every breakdown and repair should be shown. Every periodical examination and overhaul, together with a full report of all renewals and repairs, should be written up. The best method is for rough defect books to be kept by each department. From the entries in these rough books can be made the specialised typewritten entry in the loose leaf record.

Engine Room Log Book

This will vary, of course, with the store and the type of plant. It is surprising how many stores have log sheets containing irrelevant matter, and omitting the really important details. All log sheets should have columns showing details of the movement of goods in the chambers. The daily tonnages of both intakes and deliveries should be clearly shown ; and mention should be made of the condition of intakes, for it is obvious that the receipt of hot goods will cause an increase in running hours, or will explain a rise in chamber temperature.

THE CLEAR PICTURE

From internal records such as have been outlined can be formed the picture of the day to day operation of any cold store. A graph can be made which will give a clear, informative, visual and comprehensive outline of the main points of cold store operation. It is, however, impossible, from this graph, and from the records to form any analysis which would provide a clue to any wrong operation, leakage, lack of balance, or inefficiency.

Costs and technical data should be shown together. The manager, in order to run and understand his business correctly, must have complete data and costs. He should have them periodically and frequently. And he must have them so presented that he will be able to interpret them quickly and correctly.

To provide such a clear picture, records should be complete, comparative, and so presented that at one and the same time, every item can be seen individually and all items can be seen collectively.

Costs and Data necessary

There are seven main groupings of costs and data :—

(1) Engine room costs.
(2) Engine room data.
(3) Store costs.
(4) Store data.
(5) Administrative costs.
(6) Revenue.
(7) Analysis.

TOTAL OPERATING COSTS

	1	2	3	4	5	6	7	8	9	10
Month	Management Costs	Clerical Costs	Telephone Postage Stationery	Sundries Costs	Rates	Rent	Deprec.	Total Admin. Costs	Total Admin. Costs Per Cu. Ft.	Total Admin. Costs Per T.G.M.
January February Etc.										

11	12	13	14	15	16	17	18	19	20
Total Deck Costs	Total E.R. Costs	Total Operating Costs	Total Operating Costs per Cu. Ft.	Total Operating Costs per T.G.M.	Total Operating Costs per 1000 Cu. Ft.	Total Operating Costs per 1 % Space Occupied	Total Management Fees	Prog. Total Operating Costs	Av. Total Operating Costs per Cu. Ft.

Fig. 45.

It is necessary to restrict these data to essentials, and hence it is important to know which are the essential data. Refrigerating plant data must be

REVENUE

	1	2	3	4	5	6	7	8
MONTH	Total Rent on Goods Stored Controlled	Total Handling on Goods Stored Controlled	Total Rent on Private Goods Stored	Total Handling on Private Goods Stored	Other Charges	Sundry Revenue	Total Revenue all Sources	Progress Total for Year
JANUARY								
FEBRUARY								
ETC.								

Fig. 46.

complete if they are to be of any value at all. Refrigerating plants vary, and the data will vary accordingly, but for average plants, with the usual cooling systems of brine-cooled air and direct expansion piping, the data required will be similar.

Engine Room Costs and Data

Engine room costs are those for motive power, consumable stores, repairs and renewals, and wages. The motive power costs, usually electrical charges, should be split up into electrical consumption for the refrigerating plant, and for uses outside refrigeration such as heating, cooking, lifts, etc. These separate costs should be calculated in three different ways—per cubic foot capacity per month or week, per ton goods movement, and per refrigerating tonnage output.

The total refrigerating tonnage output per month should be shown, and also per ton goods movement.

Consumption of calcium, ammonia, and oils for the month, per refrigerating tonnage output, per ton goods movement, and per compressor hour run are necessary, as are also atmospheric temperature, compressor gauge readings, temperature of condenser water, of brine circulation, of storage and chilling chambers (average for month).

Store Costs and Data

Store costs and data include cost per ton handled, and cost per cubic foot capacity. Details of goods tonnage movement, intakes and deliveries of main commodities stored, average total tonnage in stock, average daily movement, tonnage speed per hour, and percentage of cubic capacity occupied must be shown. In addition, the stowing capacity per cubic foot should be calculated and shown. Necessary also, are the number of tons of each commodity in store less than one month, and in store more than three months.

Administrative Costs

Administrative costs and revenue can, of course, be reproduced from the monthly statement or periodical balance sheet. But all costs and revenue, in addition to being shown in total should also be shown per cubic foot per month or week, per 1,000 cubic feet per month, and per ton goods handled. All costs should be shown to the nearest £1, and when reducing costs to per cubic foot, etc., it will be advisable to express amounts in decimals of a penny.

Total operating costs for the engine room, the deck, and the administration, should be shown in total, and per cubic foot, per 1,000 cubic feet, per ton goods movement, and per refrigerating ton output.

Analysis

Columns under this grouping will show profit or loss for the month, per cubic foot, and per ton goods movement. The progressive totals of operating costs, revenue, and profit or loss for the year will be seen. The amount plus or minus on totals for the year and month previous will be shown. At a glance, the analysis should reveal each month whether tonnage is higher or lower, whether tonnage stored is earning and costing more or less, whether handling costs are up or down, whether engine room plant efficiency is better or worse,

	1	2	3	4	5	6	7	8	9	10	11	12
Month	E.R. Costs per Cu. Ft.	E.R. Costs per R.T.O.	E.R. Costs per Ton Movement	Total Elec. Cost	Elec. Cost Plant Only	Elec. Cost Other Uses	Elec. Cost per R.T.O.	Elec. Cost per Ton	Elec. Cost per Cu. Ft.	E.R. Costs Wages	E.R. Costs Stores	E.R. Costs Repairs
January												
February												
Etc.												

13	14	15	16	17	18	19	20	21	22	23
Total Elec. Units	Highest K.V.A. during Month	Elec. Units for Plant Only	Elec. Units Other than Plant	Elec. Units per R.T.O.	Elec. Units per T.G.M.	R.T.O. for Month	R.T.O. for T.G.M.	Average Atm. Temp. Dry/Wet	Total Comp. Hours Run	Total Fan Hours Run

24	25	26	27	28	29	30	31	32	33	34
Average Daily Hours Run Comp./Fan	Average Brine Density	Average Brine Temp. In/Out	Comp. Gauge Readings Suc./Cond.	Temp. Chambers Readings Storage	Temp. Chambers Readings Chilling	Comp. Hours Calc. lb. Consumed	Total Amount Calc. Cwts. Consump.	Total Amount Ammonia used lb.	Total Amount Oils used Pints Ref./Eng.	Av. Condenser Water On/Off

Fig. 47.

DECK COSTS AND DATA

	1	2	3	4	5	6	7	8	9	10
MONTH	T.G.M. Total Gross	T.G.M. Total Intakes	T.G.M. Total Deliveries	T.G.M. Butter Intakes	T.G.M. Meat Intakes	T.G.M. Bacon Intakes	T.G.M. Egg Intakes	T.G.M. Butter Deliveries	T.G.M. Meat Deliveries	T.G.M. Bacon Deliveries
JANUARY										
FEBRUARY										
ETC.										

11	12	13	14	15	16	17	18	19	20
T.G.M. Egg Deliveries	T.G.M. Average Daily	No. of Deck Staff	Total Deck Wages	Handling Cost per Ton	No. of Man Hrs. Worked	No. of Man Hrs. not Worked	Bonus Payment per Ton Total	Bonus Payment per Ton per Man	Speed per Man per Hr.

21	22	23	24	25	26	27	28	29	30
Speed Total Staff per Hr.	Total Cost per Cu. Ft.	Total Cost Mntnce. Repairs	Per cent. Store Capacity Filled	Storage Number Cu. Ft. per Ton	Total Tons in Store	Total Tons in Store Over 3 Months	Total Tons in Store Over 6 Months	Per cent. Store Capacity not Filled	Total Tons Req. to Fill Store

Fig. 48.

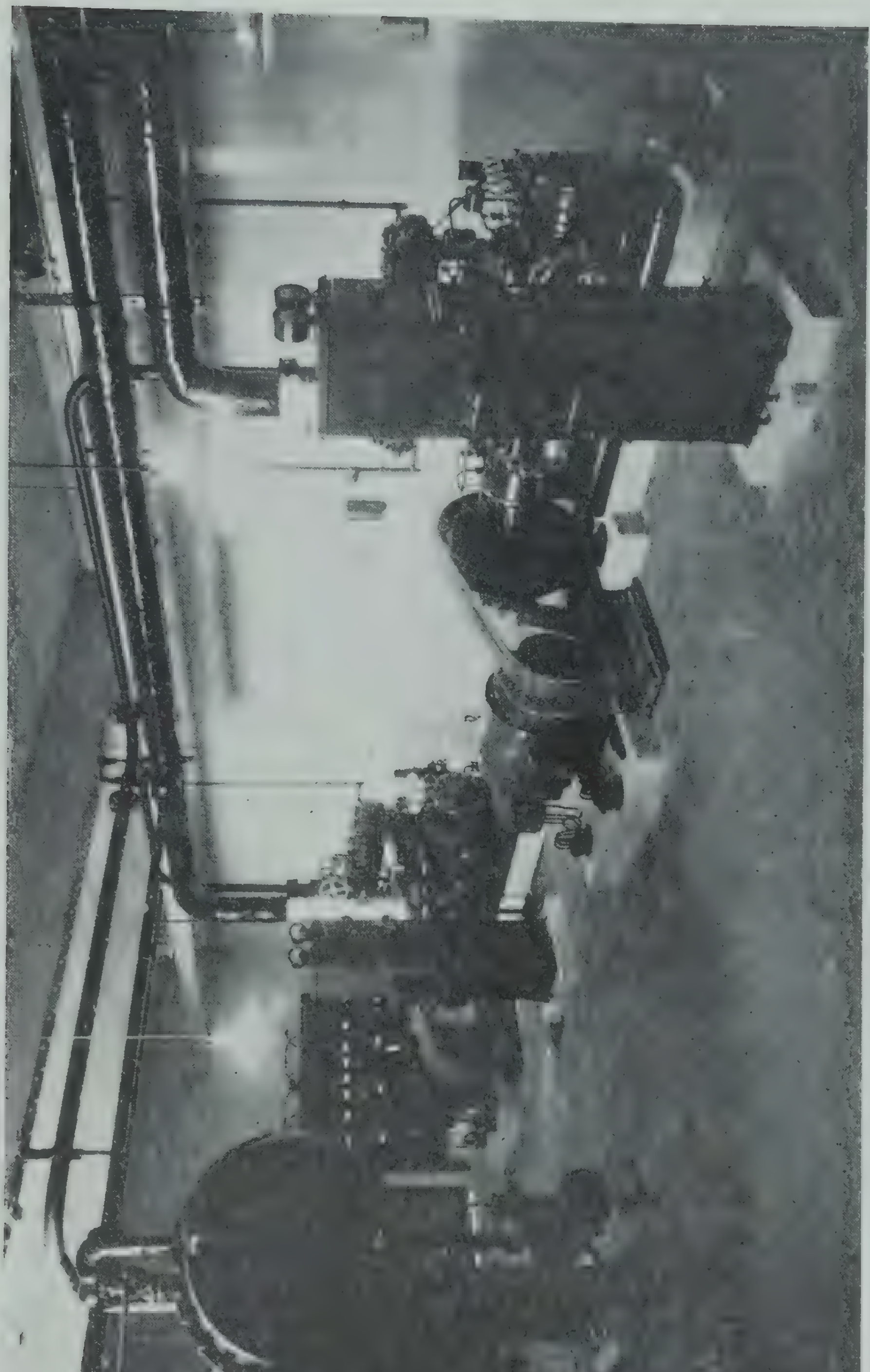


Fig. 49.—Typical Cold Store Engine Room.

and whether electrical consumption is less or more. The stowage capacity—cubic feet per ton will be visible, and also the occupancy percentage of the store.

Comparativeness

If the columns are set out as in the illustration, the extent of the comparison will be seen immediately. Divisions in the column show the figures for the previous year and for the year before that. As these are placed above and below the division of the column for the current year—the lines for the current year showing bolder than the comparative years—no confusion can possibly take place.

All columns are placed relatively. Electrical costs and data are in succeeding columns. Tonnage goods movement and costs per ton goods moved are together, as are also the different costs per refrigerating ton output.

All of these seven separate groupings can be shown on five sheets of foolscap, or on one large sheet. Thus, the complete details of one year's operation of a large or small cold store, showing monthly records of engine room working, store handling, total expenses, revenue, profit, and analysis, with each item compared with the two previous years, and including monthly totals, progressive totals, annual totals, and averages, can be seen together on the one sheet, so that immediate analysis can be made.

Such a record does not involve a great deal of work. Every cold store must, of necessity, compile this information. Setting it out in the manner indicated each month is simply a matter of extraction from the various cold store books, ledgers, and accounts.

CHAPTER 23

COLD STORAGE COMMODITY DATA

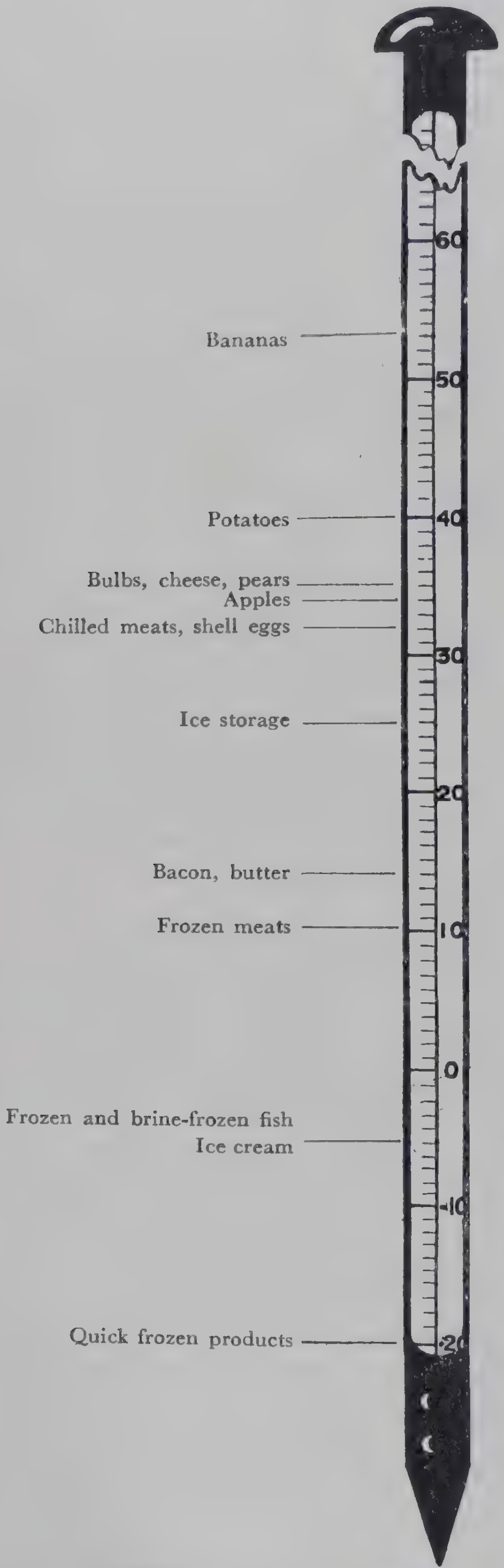
The cold storaging of perishable foods calls for a special knowledge of each and every commodity. When storage space is requested the cold storage manager must have the answers ready for a dozen or more questions relative to the commodity for which space is required. These questions are important, and he must be able to answer them before he can guarantee satisfactory storage, and before he can be satisfied in his own mind that cold storaging of the particular commodity is going to be profitable or otherwise.

Before any commodity can be accepted, the manager should know the type of storage necessary, whether chilling or freezing, whether a pipe-cooled or air-cooled chamber will be more suitable, the temperature range, the safe maximum period of storage, the humidity percentage necessary, the type of package or container, and the number of packages per ton. He must be fully aware of the necessary stowage precautions, and the handling difficulties and problems peculiar to the commodity. He should in many cases know the freezing point, the water content, and the behaviour of the commodity under storage conditions.

Commodities differ in behaviour under cold storage conditions, and require different treatment. It has been discovered that the degree of reversibility to the original state after thawing varies with the commodity. The water content, although approximating 80 per cent. in most meats, fruits, and vegetables, shows a variance with certain other commodities. This has an important bearing on storage behaviour. Because of this, cold storage commodity data are necessary, but while certain data remain constant, other data such as type of package, weight of package, number per ton, and the cubic feet per ton, are liable to change.

Table 10 on Commodity Data (see Appendix) is an attempt to collect the essential data under separate headings in the hope that they will prove useful and provide for easy reference. Only absolutely essential data are given, and no mention is made of the refrigerating load represented by each commodity, or of various other data that, strictly speaking, the manager should possess.

To complete the data necessary, an extra column showing the rate to be charged for each commodity would be useful. As a guide and a basis on which to assess rates, a list has been given in Chapter 21, but these, although operating at the time of writing, will be found to be at variance with rates operating in different parts of the country. In addition to the factor of higher and varying labour charges which will affect storage rates, it will be appreciated that to



[*Courtesy*: "*Modern Refrigeration*."

Fig. 50.—Storage Temperatures for Various Commodities.

store foodstuffs in an inland store freight charges from the ports will be incurred. Consequently, rates at inland stores must be lower than those prevailing at stores in the ports. While practically all perishable foods can be cold stored with satisfactory results, the factor of cost in addition to the requirements of supply and demand always decides whether goods are to be put into a cold store or not.

Various other data given in the table have been built up from what can only be described as experience figures. Consider storage period for example ; this is a matter on which different authorities have not always agreed, owing principally to the fact that commodities under test have not always been stored under similar conditions.

Commodities vary greatly in their condition on receipt at the store. Fruits and vegetables that have been picked a little late or have been badly packed may show a poor out-turn although storage conditions have been ideal.

For this reason a table on Commodity Data cannot be regarded as an infallible guide or the data accepted as finalised. Investigation into the behaviour of perishables in refrigerated storage is continuing, and no data can possibly be concluded until packaging and transport methods in this country have been considerably improved.

It has already been pointed out that the cause of a poor out-turn of goods from cold storage may be due to factors prevailing before the goods were received at the cold store. Ideal storage conditions are useless if—as

ery often is the case—perishable foodstuffs have been mistreated before being ent to the cold store.

Packaging methods are constantly undergoing change, and much more o-operation is necessary between the refrigerated warehouse proprietor, the acker, the transport owner, and the commodity merchant.

In compiling a table of Commodity Data that will be of service, it is therefore ossible to give only data based on experience and practice. Such experience nd practice should be as varied as possible and in as many different countries s possible. The figures in the various columns of Table 10, and the suggestions n the remarks on each commodity which follow, cannot be claimed as eing the last word. They should, however, ensure the best storage conditions or each commodity that experience and varied practice have so far discovered. 'ood technology and refrigeration are both very extensive fields and many ears of research work lie ahead.

SPECIAL REMARKS ON COMMODITIES

Ale :—Ale is not a general commodity, brewers usually having their own old rooms. Stocks held by retail suppliers in this country are too small to varrant long refrigeration. Abroad, in certain areas where breweries are bsent, it is quite a profitable commodity. If in casks, head room is lost, and ubic feet per ton occupancy is high. If in bottles in cases, stowing is close. Iumidity percentage is not important, and only a slight chill is required. sizes of casks vary from 9 gallons to 40 gallons. Casks should be stowed on ides—bungs up—not on ends. Bottles in cases may be small or large, pints or quarts. Cases may have 2, 4, or 6 dozen bottles. They are either closed ases or open. If the latter, they are fitted with divisions one for each ottle. Tare differs considerably. Temperature should be slightly higher for ottles than for casks, but consideration must be given to the type of ontainer.

Apples :—Some varieties stand up to cold storage conditions better than thers. Each variety requires special study and investigation. Storage life s dependent upon stage of maturity when picked. Packing of apples is mportant. Wrapping in oily tissues is generally advantageous. Cases or rates are made of light wood, but there is a tendency to use a heavier type of ase. This suits transport conditions better, but is not so good for storage onditions, preventing penetration of air and cold. Steady temperature, correct humidity, and frequent examination during storage are very necessary. Stow with plenty of dunnage between cases to ensure maximum ventilation. Air circulation should be slow. Humidity control is important. Low humidity prevents flesh collapse but tends to shrivel skin. Best temperature in table is given at 34° F., but although a low temperature may assist in preventing scald development, there is a possibility of increasing brownheart. Any diseased or bruised fruit should be discarded or separated.

Apple rings :—Usually received in 56 lb. cases or cartons. Keep in an air-cooled room at 33° F. with not more than 80 per cent. humidity and not less than 75. Keeping qualities are good, but mould will develop if humidity percentage is too high. Cases should be paper-lined, and wood should be free from odour. Ordinary chilling rate can be charged. Case or carton pack will stow at 120 cubic feet to the ton.

Apricots :—Packed in wood cases, individually wrapped. Cases are usually 56 lb. net and will stow at 120 cubic feet to the ton. Occasionally a smaller case is used, and frequently baskets or crates are adopted as containers. The baskets are usually bushel baskets and cases and crates are of 5 ins. by 12 ins. by 20 ins. or 6 ins. by 16 ins. by 20 ins. Picking before maturity and utmost care in packing and transport methods are necessary. Apricots will bruise easily. Two months is the safe storage period, but they have been kept satisfactorily for considerably longer. Temperature in the table is given as 35° F. with humidity of 78 per cent. Abroad, and particularly in America, a lower temperature, down to 31°, is preferred, and with the lower temperature a corresponding decrease in humidity percentage. A room temperature of 31° would perhaps be safe if storage period was expected to be longer than two months and if containers were of heavy timber. A thermometer placed in contact with the fruit in the centre of the stack would give the best reading. The temperature of the fruit must not be lower than 33° F.

Apricots, dried :—Packing and storage conditions are similar to apple rings.

Artichokes :—Should be packed in cases, crates, or baskets. Sacks are not advisable. All loose dirt and earth should be removed before packing. The artichoke is the root of an American sunflower used as a substitute for potatoes. Keeping qualities are average. Usually in store for not longer than two weeks and this is considered the safe storage period, but they have been kept for as long as two months quite satisfactorily. Storage conditions should provide for ample ventilation with fairly vigorous air movement. Temperature should be maintained at 32° F. and humidity percentage should be steady at 82.

Asparagus :—Usually packed in paper-wrapped bunches in paper-lined light wooden cases or crates of varying sizes, but popular size is 40 to 56 lb. The shoots of this lily plant make a tender eatable vegetable. Keeping qualities are not good, and care is necessary during packing, transport, and storage life. Safe maximum storage period is two weeks, but frequently the period is extended to one month. It is necessary to separate decaying shoots from good and more hardy tips. Temperature and humidity must be steady. Humidity percentage in table is given as 80 per cent. Do not exceed this. It is better to have less rather than more than 80 per cent.

Bacon in bales and boxes :—Owing to difficulties of handling, bale bacon cannot be stowed too high, and consequently there is waste of head room. While common practice is to stow six to seven bales high, four bales high is really sufficient. The higher the bales the greater the weight on the bottom bale and the more difficult it is for the vital cold air to penetrate to the centre

of the stack. Dunnage on floor should be stout, not less than 3 ins. by 4 ins., and there should be 'tween dunnage between every alternate layer. Handling is heavy and slow, each bale averages 2 cwt., and being soft, sags in the middle. Bacon generally arrives unrefrigerated and represents a very heavy refrigeration load. Providing that stacking is not too close, bacon can be hardened shortly after receipt, and will keep well in store. Safe maximum period is three months but bacon will keep longer. Temperature is generally considered to be best at 16-18° F. but experience has shown that this is not low enough. Room temperature of 14° implies that temperature of bale in centre of stack will be higher than this. Room temperature should not be higher than 14° F.

Examination of bacon in store is necessary and bales in different parts of the chamber should be examined weekly. Opening up a bale, turning the sides over so that fleshy part is uppermost, and examining for slime is the usual procedure. Inserting a steel skewer, knife, or preferably the finger near the bone and smelling for traces of taint can only be done if the bale is taken out of chamber and thawed out. This, however, should not be necessary unless there are other indications that deterioration is taking place.

Bacon in bales consists of what are usually termed Wiltshire cuts or middles. These are also shipped in half boxes—about 3 cwt. in weight. Middles are made up in small sized bales. Hams, gammons, backs, and fore-ends are invariably packed in boxes. Full boxes weigh 6 cwt. ; half boxes, 3 cwt. ; and quarter boxes average 150 lb.

Chill storage of bacon is occasionally requested. With chill storage only air-cooled chambers can be used, and the period of storage is seldom more than one month. The required temperature range is 26°-28° and humidity control should keep the percentage not more than 80 per cent. The table shows 75 per cent. This is ideal, but is difficult to attain.

Bananas :—Usually received at store either as naked bunches or "hands," or in crates, or paper bag wrapped. Crates usually weigh approximately 1 cwt. Bananas are placed in cold storage to retard ripening. They arrive ex ship, in green and hard condition. Specific conditions for cold storaging of this fruit are difficult to lay down. Everything depends upon the stage of maturity when picked, the time taken during transport, and market conditions and prices. If shipped in crates, the crates can be stowed in chambers, but if in "hands" or bunches, these must be hung, and special racks or hanging facilities must be provided. Temperature to be maintained is dependent upon state of market. It may be necessary to hasten or to retard ripening. Temperature range may extend from 40° to 55° but is usual at 50°. Heat developed by bananas inside chambers is considerable, and circulating air must penetrate the banana leaf covering the bunches. Period of storage is seldom more than two weeks.

Bass :—See *Fish, fresh.*

Beans, dried :—Received in cases or bags weighing approximately 40-56 lb. Will keep well in cold storage. Little demand in England, but abroad, refrigerated storage is necessary. Temperature range, 32°-34° F.

Beans, green or string :—The principal difficulty in cold storaging of green beans is the nature of the pack. If bags of beans are "topped," *i.e.* stowed one on top of the other, the weight is too much for the bags on the bottom, and the circulating air cannot penetrate. Racks must be fitted in the chambers so that the bags can be stowed on the racks with free air space all round. Most of the bags are of coarse hessian or close mesh string bags. Weight, closeness of stow, and lack of free air space will remove the bloom from any green vegetable. Temperature should be maintained at 35° F. and humidity percentage should not be allowed to fluctuate very far from 75 per cent. Safe storage period is usually not more than two weeks but frequently this is extended to a month. The longer the period, the poorer the out-turn.

Beef, fresh :—Freshly slaughtered carcases are split into sides and hung on hooks suspended from rails in specially fitted chill rooms. These rooms are usually about 12 feet high to accommodate length of side. Chamber doors are high and narrow, usually built in separate halves, top and bottom. Walls are tiled, and floor, if not tiles, must be cemented. Cleaning down of chamber is necessary after every intake because of dripping of blood. Sides must be hung back to back and must not touch each other. A chill room 15 feet wide by 45 feet long would be fitted with eight sets of rails and would accommodate 150 sides of beef. Soon after an animal is slaughtered, the carcase stiffens (rigor mortis) muscles and flesh tissues are shortened, and development of bacteria begins. The accumulation of lactic acid commences, and the extraction of the body heat causes a steamy atmosphere. Extractor fans are necessary in chill rooms before actual chilled air is circulated. Hanging improves the palatability of the meat, and chilling arrests the development of bacteria. The temperature of the chill room may rise to 70° after loading ; the humidity content will also be high, and temperature and humidity must be brought down to approximately 32° and 80 per cent. respectively within the first 24 hours. All freshly slaughtered beef should be hung and chilled before passing to the freezer.

Beef, frozen :—Shipped in quarters (bone-in) in hessian bags as hinds or fores. Also in small pieces (cuts). Also—particularly from Canada—shipped in cases lined with grease-proof paper. Also shipped in hessian wrappers as quarters with bone extracted (boneless) as hinds or fores or cuts. Steadiness of temperature is very important. Mould precipitation takes place at 18°. Air should not be too dry otherwise shrinkage will be excessive. If air-cooled rooms, brine density should never be less than 1,225. If pipe-cooled rooms, thickness of snow on pipes should never be heavy. Bone-in beef should be stowed on 3-in. floor dunnage. Criss-cross method of stacking is recommended. Boneless beef should preferably have 'tween dunnage every second layer or wherever practicable. Stow bags of beef cuts with 'tween dunnage where possible. Beef should be examined frequently during storage. After three months' storage, examine daily. Open up bags and examine flesh with light from electric torch for mould spots and store staleness.

Receipts arriving soft should be laid out for hardening before stowing. Bloodstained cloths should be removed. Examine on arrival for mould, damage, or brine stains possibly contracted during transport. Checkers' receipt notes must show report on condition. Report all soft and bloodstained receipts, and after hardening, stow separately. Stow hinds separate from fores, boneless separate from bone-in.

Beer :—See *Ale.*

Beets :—Received in light wood cases or mesh bags of approximately 40-56 lb. weight. All dirt and earth should be removed before storage. Careful stowage is necessary, and rough handling will result in spoilage. Keeping qualities only fair. When packed in baskets, stowage is easier.

Blackberries :—Received in cases or baskets. There are various kinds of baskets. A chip basket is a small light affair holding approximately 10 lb., and having a paper top or cover. A larger type of basket frequently termed a hamper is usually round, tapering towards the bottom. Bottom diameter is 10 ins. and top diameter is 15 ins., with an overall height of 18 ins. Such baskets average 50 lb. in weight. Cases of 12 ins. by 12 ins. by 20 ins. also average 50 lb. Packs are various so that it is necessary to weigh one of each type of pack for charging purposes. As with all fruits humidity percentage is of first importance. Blackberries require not more than 80 per cent. and not less than 75. Rather slow air circulation has been found to be advantageous and, with a temperature range of 33°-36° F., blackberries will show satisfactory out-turn as a rule. Three weeks is recommended as maximum safe storage period, but they have been kept longer than this.

Blood :—Stow in an air-cooled chamber. Blood is a perishable fluid and deteriorates rapidly. Above a chilling temperature it will develop bacteria and spoil. For industrial purposes blood is sent to cold stores in canisters direct from abattoirs but is seldom stored longer than one week. Temperature fluctuations must be avoided and a temperature well below chilling is frequently desired by industrialists handling blood. Blood canisters are usually 3-5 gallon size. Best temperature is 25° F.

Blood plasma :—Blood for medical purposes is sent to cold stores in 6 ounce capped bottles. Great care must be taken with human blood. Blood plasma is a precious fluid and not easy to replace. The bottles are in cartons or crates. Stow in an air-cooled chamber with a steady temperature range of not more than 38° F. Whole blood should be stored at 32° F.

Bluefish :—See *Fish, fresh.*

Brisket :—See *Meats, fresh.*

Bulbs :—Received in trays about 2 feet square and 6 inches deep, usually about August and held until October. Hold at 35° F. with gentle air and humidity at 80 per cent. As trays are open it is necessary to stack criss-cross.

Butter :—A fairly safe commodity, easy to handle. Stows compactly if in cases or cartons. If in casks handling is more difficult. Casks are usually 1 cwt., but cases and cartons are 56 lb. Butter from New Zealand or Australia

arrives in hard frozen condition, and being slow to thaw, represents small refrigerating load. Continental butter, usually in casks, arrives only semi-refrigerated and requires hardening. Floor dunnage only is required. Five cases high approximates floor load of 300 lb. per square foot. With compact stack, height can be increased with load spaced equally over whole floor area. It is advisable to stow away from walls. Butter absorbs odours so that where possible stow away from other goods. It is always beneficial to operate an ozonator periodically in a butter room. High humidity percentage or any damp condition is detrimental. Occasionally a box of butter should be opened and tested. Scrape a little from top or sides of butter block and hold in mouth; note taste when completely thawed. Smell paper and box or container. Butter should be stowed according to country of origin, and also shipment. Separations should also be made for factory, class, and quality.

Buttermilk :—Not often received but same conditions as milk.

Cabbage :—Usually received in crates about 2 feet square and 3 feet high. Also shipped in barrels about 2 feet 6 inches long and 18 inches diameter at ends. More often—if from local farms—cabbages are packed in nets and bags in which they cannot be topped. Bags will not support weight, and racks are necessary. Air circulation and ventilation must be free and thorough. All dead leaves and dirt should be removed prior to storage. Humidity percentage should be low and steady. Dampness causes loss of bloom and accelerates deterioration.

Canned goods :—Only adequate ventilation necessary.

Carrots :—Sent to store in mesh bags, baskets, and crates. If in mesh bags, stowing cannot be too high otherwise bottom bags will suffer. All dirt should be removed prior to stowing. Thorough air circulation and fairly low humidity produce best results. Prolonged storage and too much humidity result in tendency for carrots to develop mushiness.

Casings :—Sausage casings are a valuable commodity and require steady temperature and humidity. Storage temperature of 12° is necessary, and care should be taken that stow is not too tight.

Cauliflower :—Packed similarly to carrots. Racks are advisable and stowing should be fairly loose. Handling requires care. There is considerable heat generation with cauliflowers. Excessive humidity causes rot. Safe maximum period of three weeks can be extended, but loss of bloom, change of colour and rot should be carefully noted. Goods should be withdrawn on first sign of deterioration.

Celery :—Conditions on arrival at cold store are important. Celery develops rot and mushiness very quickly. Fluctuations of humidity content and temperature are contributory factors to rot development. Rotten stalks should be removed daily.

Cereals :—Dry chill temperature necessary and care must be exercised in stowing. Examine periodically for presence of insect pests.

Cheese :—Cheese packs vary according to the variety and the country of origin of the cheese. The principal cheeses, such as Swiss, Roquefort, American, New Zealand, English, and Canadian cheddars, are usually packed in crates and cases, two cheeses to a case, each cheese weighing approximately 40 lb. Smaller cheeses, such as Dutch, cream, and other varieties, are made up in smaller packs, contained in an outside container, usually 50-60 lb. in weight. Gorganzola and more mature cheeses keep better than cheddars. The keeping qualities of cheeses vary greatly, and behaviour under storage conditions depends to a great extent on the stage of maturity. Turning cheeses while in store is a long established practice. Generally, cream cheese and the sweeter cheeses require a lower temperature than cheddars. The latter are satisfactory if kept at 38° but the former are better at temperatures near freezing point. As a general temperature, 35° F. gives very good results, but humidity should be kept at not more than 80 and not less than 75 per cent. Most authorities agree that cheese should not be frozen because the degree of reversibility to the original state on thawing is more marked with cheese than with other commodities. In tropical countries, however, cheese is kept in a frozen temperature, but consumption must be immediate on delivery from store. Generally, however, cheese keeps better in a chill temperature, and freshness remains for a considerable time after cheese is brought out of store, and cut. Cheese deteriorates rapidly after the temperature has risen above 50° F., and especially if there is high humidity content. Stowing can be compact, and providing temperature and humidity are steady, there is little to fear. An ideal cheese room is one fitted with special racks so that each cheese case, crate or naked cheese, is separate.

Cherries :—There are many packs for cherries. In England, they are sent to store in small chip baskets, in hamper baskets or in crates. Abroad, they are packed in a variety of carton containers, particularly of the cup type, and in various forms and sizes of baskets. They are mostly short period storage, but will keep longer, depending upon stage of maturity at time of picking. Cherries are not subject to usual fruit diseases and will keep well providing storage conditions are ideal. As with most fruits, steadiness of both temperature and humidity is essential. Frequent inspection is necessary, and wet or mushy fruit should be separated. Sour varieties are less satisfactory under storage.

Chestnuts :—High humidity accelerates deterioration, and chestnuts will quickly develop mould. Bags are a poor pack, but they are invariably used. Air circulation should be fairly strong. If possible, chestnuts should be sorted while in store and any in poor condition should be separated. Hold at 33° F. and 75 per cent. humidity. Lower temperature after three months' storage, and carefully examine if longer storage is necessary.

Chocolate :—Usually packed in cartons of various weights, but generally averaging 50-60 lb. Occasionally, these cartons are packed in wood cases averaging 3 cwt. Air rooms are necessary, and 40° temperature is all that is

required. The important storage condition is humidity. Chocolate reacts quickly to excessive humidity. Bloom will be lost if humidity is maintained above 80 per cent., and the most satisfactory percentage is 75. Stow loosely with slow but thorough air circulation.

Cider :—Cider requires a slight steady chill. Stacking can be fairly compact, and providing the temperature does not fluctuate no trouble will be experienced. If cider is offered in barrel form, the barrels should be stowed on their sides. Cider is usually received in bottled form, quart, pint, and half-pint bottles, packed in cases of two, four, and six dozens.

Cod :—See *Fish, fresh.*

Cod brine :—See *Fish, frozen.*

Compound lard :—Similar storage conditions are required for lard compound as for margarine. It is packed somewhat similarly and its behaviour in storage is also much the same. Humidity is all important and a dry atmosphere is very necessary.

Cream :—Packed in bottles or cans. Both bottles and cans are usually small, seldom more than half-pint size. These are usually packed in wood cases. For short-term storage cream is usually stored in a chill chamber. Generally, however, it is better to store cream at a low temperature and 0° F. and even lower is necessary for long period storage.

When cream is withdrawn from low temperature rooms, consumption must, of necessity, be immediate. Thawing will be accompanied by a separation of fats, and the cream will be useless if kept too long.

Crêpe rubber :—Crêpe rubber is occasionally offered during the hot summer months for chill storage. It arrives packed in wooden cases of 1-3 cwts., and requires 31° F., and a low humidity percentage of not more than 75.

Cucumbers :—Received either in baskets or bulk. Temperature and humidity fluctuation definitely accelerates rot. Too low a humidity advances the rate of deterioration. Air should be slow and penetrating. Water content is high, and storage period is seldom more than a fortnight.

Currants :—Little difficulty with this commodity, which is usually received in paper-lined cases or crates. Steadiness of temperature and humidity is very desirable because mould can grow easily on currants.

Damsons :—Usually packed in paper-lined cases, but are also received in the ordinary chip and hamper basket. Are subject to mould, and require careful examination for separation of bruised, mushy or decayed fruit. Usual steadiness of temperature and humidity percentage necessary. Gentle air, and loose stowing.

Dates :—Received in two grades, dessert and cooking. The dessert type are packed in the familiar paper-covered half-lb. box packed in an outside container, usually a wooden case. The cooking type are usually pressed into half-cwt. blocks and packed in paper-lined wooden cases. Dates easily develop mould when humidity is high or fluctuates. Range of humidity should be between 75 and 80 per cent. Stowing can be fairly compact.

Eggs in shell :—Packed in light wooden cases that are really crates in that the boards forming the case are nailed so that there are spaces between them. The eggs are packed either in cardboard fillers and flats divisions or in wood shavings or excelsior packing. Eggs in shell are a principal commodity in cold storage warehousing but require especial care. There are cold stores specially constructed for this commodity only, and no other commodity whatever is handled. Steadiness of temperature and humidity is of supreme importance. Temperature must be maintained to within half a degree. Humidity percentage range is between 78 and 82. Air circulation must be slow, and any cases directly under delivery ducts should be shielded from delivery air by deflecting boards. Cases should be stowed on ample floor dunnage, and with 'tween dunnage between every case. 'Tween dunnage need not be more than one inch. Eggs absorb all odours, and chambers should be scrupulously clean. Many stores use unslaked lime on floor, and in air ducting, but this is not advisable while the eggs are in chambers because of their absorbing properties. During " off " season months, egg chambers should be thoroughly limewashed, and this should be completed well before the new egg season commences, so that thelime wash will be quite dry. Consistent use of ozonizing plants is necessary. Ozone lessens absorption of odours. No other commodity should be stored in egg chambers, and air batteries should be confined solely to egg chambers, and not in conjunction with other chambers. Even during " off " seasons when chambers are standing empty—usually from December to March —it is not advisable to use these chambers for anything else but eggs.

The dimensions of the " long " or 120 dozen case are usually 6 feet by 3 feet by 6 inches. The dimensions of the 30 dozen case are 15 inches by 15 inches by 26 inches. There is a smaller case 12 inches by 12 inches by 24 inches. Stowing should not be too compact, and the usual practice with long cases is to stow two tiers together, and leave a six inch space before building the next tier. Walking space should be left between all walls and tiers, and at least two central gangways are necessary both down the length and breadth of the chamber.

On withdrawal from chambers, defrosting of eggs is advisable to eliminate cracks and other faults which may accompany too rapid a change from a temperature of 31° to that of the atmosphere. This is a service usually given by the cold store. Outside the egg chamber is a small chamber in which an electric blower fan and heating coils are installed. Warm air with controlled temperature is circulated slowly over the egg cases placed in the special chamber. (See Chapter 13 on Eggs.)

Egg, liquid, frozen in tins :—Received in tins both square and round, naked, wrapped in hessian wrappers, in cases or in cartons. There are various sizes, 44 lb., 40 lb., 30 lb., 28 lb., 22 lb., 11 lb., and 5½ lb. Frozen egg keeps well and is easily handled. Stowing can be compact, but care should be taken that " bad pockets " are avoided in badly shaped chambers. There have been instances of frozen egg stacks being discovered defrosted while other stacks

in the same chamber have been in a good hard condition. When stacks are large 'tween dunnage should be used. Separations should be made for different marks, ships, and so on. Liquid egg can be "frozen mixed," "frozen yolks," and "frozen whites" or albumen. Receipt and storage involve comparatively little work, but deliveries call for a great deal of attention because of small parcels for different consignees.

Egg, dried :—Flake egg keeps well providing no unduly humid condition is allowed. So long as there is free air circulation with a humidity percentage of not more than 80 per cent., flake egg will keep at 32° F. for three weeks. Longer storage period necessitates a lower temperature, and at 12° F. flake or dried egg will keep perfectly for twelve months and more. Flake egg is usually shipped in 100 lb. tin-lined wooden cases. When made up into the small retail packets these are usually packed in half-cwt. cartons and kept in chill temperature.

Figs :—As with dates, figs are received in two qualities—dessert and cooking, and the pack is also similar. The same storage conditions are necessary but a slightly lower temperature is advisable.

Fish, fresh :—It is difficult to generalise about fish, but it is necessary, because frequently many varieties must be stored together. Actually fish cannot be treated as one commodity. Each variety differs in fat content, weight, pack, and so on. The usual fresh fish sent to cold stores are plaice, herring, and cod, but depending on the locality, any other variety may be sent either in large or small parcels. Fish may also be sent for short-term storage for which only a "strong chill" is required. Some cold stores receive quantities of shrimps, others oysters. Other stores may see nothing but the common mackerel. This refers principally to the inland store. Port stores will receive fish in bulk, and the variety of fish is limited by the locality of the fishing grounds served by ships from that particular port. The traffic in fresh fish at the inland stores is usually confined to unsold stocks, and short-term storage only is required. A pipe chamber with temperature maintained at 15° is suitable. If remaining in storage, fish, after being hardened in this chamber, should be transferred to another chamber not subject to hot intakes. When traffic in fresh fish is heavy and consistent, then suitable heavily piped chambers should be used, with the temperature maintained at from 0° to 5°. Frequently, where fish is put into store overnight, or for the week-end only, a chamber maintained at about 25° is all that is necessary.

The water contents of various fish differ considerably, as can be seen by the following :—

Bass, 77 per cent. ; cod, 82 per cent. ; flounder, 84 per cent. ; herring, 72 per cent. ; mullet, 75 per cent. ; salmon, 64 per cent. ; sturgeon, 77 per cent. ; turbot, 71 per cent. ; trout, 77 per cent.

Fish, cured :—Cured fish such as kippers, haddies, and so on, will keep well in a chill temperature for short periods providing that humidity percentage is low. For long period storage cured fish must be kept in a low temperature

and they should be carefully examined for mould development throughout the period of storage. On delivery from freezing temperature, cured fish should pass into consumption as soon as possible. Humidity percentage is all important in the storage of cured fish. Too low a humidity percentage causes shrinkage, too high encourages mould. Fluctuation of either temperature or humidity causes mould deposit also, so that a free steady slow air circulation of the right temperature and dryness is absolutely necessary. If chill storage, hold at 32° and 78 per cent. humidity.

Fish, brine frozen :—See *Fish, frozen.*

Fish, dried :—See *Fish, cured.*

Fish, frozen :—Cod, hake, salmon, turbot, and so on, arrive in cases containing two and three stone in weight. Quick-frozen fish—usually fillets—arrive in small carton packs. Zero degrees is the highest temperature that should be allowed for frozen fish and, generally, fish rooms are maintained at minus 5° F.

Flowers :—Flowers arrive in cartons and light wood cases. Care must be taken in stacking because weight may crush the contents. Temperature should be maintained at 34°-40° F. with humidity percentage at 80-85. Bloom will be preserved under these conditions even with the most delicate varieties. Two weeks is given as the safe maximum period, but with the more hardy species this can be extended.

Fruit juices :—Concentrated fruit juice—particularly orange juice—is packed in gallon cans, six cans to the case or carton. Stowing can be compact. Care must be taken to stow according to marks, shipment, and month. Storage conditions required are 80 per cent. humidity and 34° F. temperature. There is little trouble with this commodity.

Furs :—Furs, carpets, and tapestries are occasionally offered to the general cold stores but usually are sent to a specialised store. Some specially constructed cold stores handle the fur trade exclusively. Furs, carpets, tapestries, and anything of this nature forming suitable feeding grounds for moths can be kept in chill storage for long periods. A chill temperature of 34° F. with low humidity of 60 per cent. will prevent germination. It is estimated that 34° will kill all moths within a month, but zero degrees will kill them instantly. A growing practice is first to employ heat to hatch the moth eggs, and then to lower the temperature to zero to kill all possible insect life.

Game :—Game such as pheasant, ptarmigan, and so on, is usually sent to cold stores as shot, without dressing of any kind. If sent without packaging, hang from rails or hooks. Will keep satisfactorily under steady temperature of 33° F. and low humidity, but if long period storage is required, game must be frozen after cooling down and should not be stored higher than 12° F.

Game, frozen :—Packed, similarly to poultry, in cases approximating half cwt. Weight and pack vary according to the bird. Hold not higher than at 12° F. and stow with plenty of dunnage.

Gooseberries :—Packed in approximately 40-56 lb. cases, paper-lined. Keeping quality under storage conditions is comparatively quite good, but steadiness of temperature and humidity percentage is very necessary. Circulating air should be moderate. Ozonizer should be used frequently. Gooseberries usually develop considerable heat and for the first few days the room temperature can be lowered a degree or so, afterwards allowing it to rise to 34° and then keeping it steady.

Grapes :—Usually received in paper-lined cases with each 1 lb. bunch separately wrapped, or in barrels filled with cork dust or shavings as packing medium. Easily bruised. If in barrels, it is difficult for circulating air to penetrate. If in cases, storage period can be up to six weeks, depending on their maturity on arrival. Should be sorted before packing, and any wet, bruised, or over-ripe, should be discarded. If pre-cooled after picking, storage period can be extended.

Grapefruit :—Grapefruit is a citrus fruit liable to fermentation. Similar storage conditions as with oranges and lemons are suitable, and behaviour under storage conditions resembles that of oranges and lemons. Depending on maturity, storage period of one month is quite safe. If not too ripe on arrival, storage period can be extended, but fruit should be examined daily. If anything, grapefruit is more hardy than oranges, and it has a less penetrating smell. Any damaged or bruised fruit should not be stored.

Haddock :—See *Fish, fresh, cured, and frozen.*

Haddock, brine frozen :—See *Fish, fresh, cured, and frozen.*

Halibut :—See *Fish, fresh, and frozen.*

Hams, smoked :—Received in units, paper or cloth wrapped or both, or in cases of 1, 3, and 6 cwt. Short-term storage requires only a chill temperature, but generally, a freezing temperature is necessary. If kept at a chill temperature, a room temperature of 28° F. is advisable. Keep humidity percentage fairly steady and low. Watch for shrinkage because evaporation can be extensive.

Honey :—Packed in bottles or glass jars in cartons or cases. Requires chill temperature only. Careful handling is necessary.

Hops :—After drying, either by the sun or in kilns, and pressing into bales, hops are sent into cold stores and held for fairly long periods in order to retard the resinous and aromatic changes which take place during ageing. The refrigeration load is small, and the revenue earned is not high, but it is a remunerative commodity in that operational costs are low and storage life is long. Temperature should be steady, and humidity percentage should be low. During storage, note colour and smell and, if changes are too marked and too rapid, both temperature and humidity percentage must be lowered.

Ice :—Ice is hardly a commodity but it must be kept in cold storage if it is to be preserved. There are three points of interest worth noting in connection with ice storage. Sticking, breakage, and shrinkage are three problems of ice storage that require continual attention. Sticking is caused by fluctuating temperature, and in some stores grass mats are used between the ice blocks

as a preventive. Breakage is caused by forcing the blocks apart after sticking, by bad stowing, and by rough handling on delivery. Shrinkage is a result of breakage, and also of high and fluctuating temperature. Ice blocks should be stowed on sides rather than on width or faces. The accepted temperature is 28° but 25° F. is more advisable. Storage period can be indefinite but stocks are usually cleared each year.

Ice cream :—A low temperature is necessary for ice cream, not more than 5° F. and preferably lower. Ice cream storage must not be confused with ice cream hardening. Chambers for ice cream storage are usually constructed so that the cooling pipes are made to form storage racks. Packs are usually in carton form, but ice cream may be offered for storage in bulk, in churns and trays, before packaging.

Jams :—Not often offered for storage, but chill temperature only required. Care is required in handling.

Kippers :—See *Fish, cured.*

Lamb :—Conditions generally as applied to meats cover lamb carcases and cuts. Freshly slaughtered lamb carcases are hung in chill rooms. Frozen lamb is imported from New Zealand principally but also from other countries and arrives ex ship, hard frozen, and wrapped in cloths. Lamb carcases should be stowed alternately bellies up and on sides criss-cross. This allows maximum air flow and tends to prevent slipping or riding of stacks. Lambs attract mould very quickly if storage conditions are not good, and inspection while in storage should be frequent. Too much humidity will cause carcases to stick together, resulting in damage when breaking apart. Care should be taken that no soft carcases are stowed in stacks.

Lard :—Same conditions and same pack as compound. Humidity is most important. The percentage should be low and constant.

Lemons :—A citrus fruit with usually better keeping qualities than oranges, and less gas concentration. Lemons must not be stored with any other commodity. Condition on arrival is important. Damaged fruit should be discarded. Storage conditions are approximately the same as for oranges. Pack is also similar. Humidity percentage should be low and constant.

Lettuce :—As with cabbage, parsley, cauliflower, and so on, lettuce is quickly affected by an atmosphere which is either too dry or too humid. Bloom and freshness are easily lost. Racks are necessary as lettuce cannot be "topped." Storage life is short. Dead leaves should be cleared as frequently as necessary.

Limes :—Same storage conditions as with lemons but limes are not quite so hardy and storage period is necessarily shorter.

Lobsters :—Received in barrels or tubs and occasionally in cases. Usually packed in ice. Require constant care and should not remain in storage longer than one month. Storage behaviour depends on condition when received, and careful and frequent examination is necessary.

Maize :—As with all cereals in storage, humidity is of first importance. Storage period is short.

Malt :—Stands up well under storage conditions. Keep humidity percentage low and constant. Stow loosely.

Margarine :—Margarine keeps well under controlled humidity conditions and with a slight chill. Received usually in half-cwt. cases and stows compactly. Margarine should not be frozen.

Meats, cooked :—Cooked or processed meats, tongues, galantines, and so on are frequently sent to cold stores. Usually, it is for short-term storage only, in which case only a chilling temperature is necessary. Longer storage than two weeks necessitates lower temperature, and it is advisable to store at not higher than 12° F. Packs of cooked meats may be in tins, glass jars, cartons, or paper wrapped. If chill storage, 34° and 75 per cent. humidity is satisfactory. Cooked meats will develop mould very quickly with excessively humid conditions.

Meats, fresh :—See *Beef, fresh.*

Meats, frozen :—See under *Beef, Lamb, Pork, frozen.*

Melons :—On arrival store in room at temperature of 31° and hold for three days at this temperature. Then allow temperature to rise a little and maintain at 35° F. Keep humidity percentage low and steady.

Milk :—Milk usually arrives from dairy farms in glass-lined tanks and churns by road and rail. Where milk is cold stored there are usually bottling and washing machines so that the milk may be bottled and stored in chill rooms ready—in bottles—for the following day's delivery. Or the churns may be placed direct into the chill rooms, and the milk bottled following delivery from the chill room. Milk will absorb gases, odours, and so on when warm and must therefore be stowed separately from any other commodity. Freezing point is slightly lower than that of water. Milk is usually held at 37° F. Bacteria are not killed, but will lie dormant at this temperature.

Milk powder :—When all water is evaporated from milk, the result is milk powder. This can be restored to milk by adding water. Milk powder stored in temperatures above 45° F. develops an "off" condition, due to the chemical change which takes place in the fat. Above 50° the chemical change is fairly rapid. For this reason it is advisable that all milk powders should be stored in a temperature under and never above 40° F. At 35° milk powder will withstand fairly lengthy storage. Humidity percentage should not be more than 75 because, even with a low temperature, excessive moisture will accelerate deterioration of milk powders.

Mushrooms :—Usually packed in the chip form of basket, with paper lining. Occasionally, also packed in thin wooden paper-lined cases. Storage life is short but will keep one month with steady temperature and humidity. Safe maximum period should, however, be regarded as two weeks.

Mushroom spawn :—Same storage conditions as mushrooms. Spawn will lie dormant for a month under chill storage conditions, but tends to germinate or die over this period and above 36° F. Air should be gentle.

Mutton :—See *Meats, fresh* and *frozen.*

Nectarines :—Not often received. Handle with care and stow loosely. Hold steady at 35° and examine frequently.

Nursery stock :—See *Flowers*.

Nuts :—Nuts usually stand up well under storage but require vigorous air circulation and steady humidity percentage conditions. Hold at 34° F.

Oatmeal :—See *Cereals*.

Offals :—So far as cold storage commodity data are concerned, beef, lamb, and pork offals are in the same category as fresh and frozen meats. Fresh offals are sent to cold stores for chill room storage when the plucks are taken from freshly slaughtered carcases. Imported offals are received in the frozen state in hessian bags, cases, and cartons. Kidneys, hearts, tongues, livers and so on are all stowed separately and deliveries are made from the separate stows. Offals are quickly affected by fluctuations in temperature. Humidity precipitates mould very quickly on offals. Stowing should be carried out with care to ensure maximum air flow through stacks. 'Tween dunnage is advisable.

Onions :—Received in half-cwt. crates and must be stored separately. Smell is very penetrating and other commodities will quickly absorb odour. Stow very loosely and allow maximum air circulation. Fluctuation of temperature and humidity will cause excessive sprouting.

Oranges :—A citrus fruit with a very penetrating gas. Oranges must be stored separately and well away from meat chambers. Oranges should be sorted before storing and any bruised, damaged, or deteriorated fruit should be discarded. Oranges should be picked in dry weather and handled carefully to avoid bruising especially near stem. Blue mould attacks oranges, and any so affected should be treated with a light borax solution. As with onions, oranges are a dangerous commodity to store because of gas and smell which will be absorbed readily by other commodities. Temperature and humidity should be kept very steady.

Orange juice :—See *Fruit juice*.

Oysters :—Oysters are packed in bags as well as tubs. Storage is attended with risk. Oysters quickly deteriorate. If packed in bags, the bags should be kept moist. If packed in tubs, the oysters should be packed in with crushed ice. With tub pack maintain temperature slightly below that given in Table.

Parsley :—Received in string or net bags. Must be stowed on racks to prevent "topping." Gentle air and correct humidity and as little fluctuation of temperature as possible will preserve freshness. It is seldom a long storage commodity and two weeks is the maximum period.

Parsnips :—Occasionally received in crates but usually packed in bags or nets. All dirt should be removed before storing and deteriorated roots should be discarded. Humidity percentage should never be above 80. Bags should be opened frequently and only sound parsnips allowed to remain.

Peaches :—Peaches are a delicate commodity and require a great deal of care. Time of picking, method of packing, handling, stowing, and conditions during storage are all important. Picking should take place before maturity.

They should be precooled, wrapped individually, and packed with extreme care so that no possible bruising can take place. Air should be gentle ; stowing should be loose so that air circulation is thorough.

Peaches, dried :—Same conditions as *Apricots, dried.*

Pears :—There are considerable differences in the storage behaviour of pears according to the variety. Pears should be precooled on picking, which must be before maturity. Wrappers are necessary and handling must be such that bruising is avoided. Blackening is the result of storage without wrappers. Each variety requires separate study for storage behaviour and with certain varieties a lower temperature than 36° procures better out-turn. Temperature should never be below 31°.

Peas, dried :—Packed in cases or bags. Keeping qualities are good. Hold at 33° with 75 per cent. humidity.

Peas, fresh :—Care is necessary when stowing. Cases are easier to handle than the bags in which they are sometimes packed. Peas should be sorted before storage and only sound peas admitted. Any wet peas or peas with pronounced blackness should be discarded. Air circulation should be gentle.

Pineapples :—If shipped as picked will keep fairly well with steady but low humidity percentage. Temperature should not be below 40°.

Plants, potted :—See *Flowers.*

Plums :—During the season plums are a plentiful commodity for which considerable chill space is requested. Most varieties are hardy, but the Victoria stands up better than any. Storage period depends upon maturity when picked and when received into store. Usually packed in paper-lined cases, open trays and boxes, and with steady temperatures will keep in good condition for six weeks. After the first three weeks in storage, inspection should be frequent.

Pork, fresh :—Same conditions as for *Beef, fresh.*

Pork, frozen :—Pork usually stands up well under cold storage conditions. Frozen pork may arrive as a full carcase, as a side wrapped in paper and cloth, as two sides forming one bale, in boneless form hessian wrapped, in cuts averaging 10 to 14 lb. packed in hessian bags, or in cases weighing approximately 75 lb., or in cartons. Pork or hog sides will develop mould quickly in humid conditions. The same care must be taken in stowing as with beef and lamb.

Potatoes :—Cased potatoes store much better than bags or sacks. Timbers of cases should be half an inch apart to allow thorough ventilation. Potatoes should be clean and dry. Humidity percentage should never be above 80 and must not fluctuate.

Poultry :—If received fresh for freezing, poultry should be hardened in a separate chamber before storing. Poultry should be packed in light paper-lined cases. Dressed poultry and rough plucked poultry should be stored. Poultry is liable to mould spotting, and should be examined frequently.

Prunes :—Same conditions apply as with dates. Stand up well to chill storage conditions. Steady temperature and humidity percentage desirable.

Pulp fruit :—See *Fruit juice.*

Rabbits :—Fresh rabbits are frequently sent into cold store exactly as they are killed, packed into cases or hampers, usually much too close, and in such a way that cold cannot penetrate. The most satisfactory method is for rabbits to be brought into store before packing, hung from hooks or over rails in pairs or over sides of hampers. When thoroughly hardened, rabbits should be packed in paper-lined cases, heads and tails, twenty-four to a case. After packing, store in another chamber and hold at 10°-12° F.

Imported rabbits arrive in cases, either skinned or unskinned. There is quite a big trade in imported rabbits, and as a commodity they are well worth while. They make quite a compact stow and keep satisfactorily for long periods at 10°-12° F.

Radishes :—Packed in either cases or net bags. They are usually sent into store with too much green top. Keeping qualities are fairly good. There is a certain amount of difficulty in stowing, especially if packed in nets, and usually racks are necessary. Similar storage conditions as for most green vegetables are suitable.

Raspberries :—Keeping qualities are not very good, and great care is necessary. Mould and mushiness are usually the result of prolonged and poor storage conditions. Low humidity is required and not more than two weeks' storage.

Rhubarb :—Seldom offered for cold storage, but should be packed in crates. With low humidity and steady temperature rhubarb will keep for two weeks.

Rice :—Same conditions as for *Cereals.*

Seeds :—Packed either in cartons or trays. Very low humidity is necessary, and temperature should not be below 36° F.

Serums :—Can be kept in either chill or frozen storage. If long period storage is required, serums keep better if stored at 15° F.

Skins :—Same conditions as for *Furs.*

Strawberries :—Usually received in the chip form of basket, known as the handle basket. Similar to raspberries in that storage period is short and the most careful storage conditions have disappointing results.

Syrup :—Usually received in tins and requires conditions similar to those for fruit juices.

Tangerines :—More hardy than oranges, but similar storage conditions necessary.

Tobacco :—The important condition for tobacco storage is humidity percentage. It must be steady and must be correct. Usually tobacco is held at 75 per cent. with a temperature of 35° F. But the condition of the tobacco itself usually determines the storage condition required. If weevil is present then the temperature must be lowered at least to 10° F. in order to kill the weevil.

Tomatoes :—Cold storage for tomatoes is not often sought in this country. During the season, tomatoes are plentiful and cheap. During the off season

months, tomatoes can be imported from abroad at a fairly reasonable price. Cold storaging of tomatoes requires considerable care. Success depends on time of picking, and to a great extent on the variety of the tomato. Generally, if tomatoes are picked about three-quarters ripe, packed in trays, held at 35° and 80 per cent. humidity with moderate circulating air, storage period of twenty-one days can be ensured.

Tongues, pickled :—Usually packed in barrels with strong pickle or brine solution. Held at 12°-15° F., the out-turn is usually quite satisfactory.

Turnips :—Usually received in bags and require cooling down. All dirt should be removed before storing. Storage period is not long and sorting during storage is necessary. Low humidity percentage is necessary and air should be vigorous.

Turkeys :—Similar conditions to those for poultry and game. Imported turkeys are packed in cases and care must be taken on delivery to note weights, —net, tare, and gross.

Vaccine :—See *Serums*.

Veal, boneless :—See *Beef, frozen*. In stacking use plenty of 'tween dunnage.

Watercress :—Same conditions as for *Lettuce*.

Wines :—Stow on sides.

Woollen goods :—See *Furs*.

Yeast :—Yeast may be packed in 1 lb. packets in cartons or cases, or in 5 lb. bags, or in 2 oz. packets. A chill temperature with low humidity is necessary and storage period is short. For long-term storage it is necessary to store at low temperature, but it must be used immediately on delivery from low temperature storage. Yeast is particularly susceptible to humid conditions and care must be taken that humidity percentage never exceeds 80 and is kept as steady as possible.

General Summary

The results of poor cold storage conditions are loss of flavour or palatability, oxidation, desiccation, general deterioration and breakdown, and mould ; rancidity becomes quickly apparent if the commodity stored is fatty or oily. In the avoidance of these conditions it will be seen from the above brief notes that temperature, humidity percentage, and method of stowing are the three main considerations. Steadiness of temperature and humidity percentage are particularly of the utmost importance.

The accurate control of humidity is the province of the engineer, and these notes for the cold storage operator are not intended to encroach on any technical field. It is nevertheless necessary for the operator to see that his sphere of operation will not unduly affect either temperature or humidity percentage. Heavy intakes of hot goods, and continuously open doors are the principal contributory factors : the first of these cannot be avoided, but the second can. Close stowing, by blocking air circulation, also increases refrigerating load (in addition to endangering and greatly reducing the storage

life of the commodity) and methods of stowing and stacking must be adapted to suit each particular kind of pack received. It is unfortunate that the type of package selected for a commodity is a matter over which the cold store operator has little or no control.

The increasing use of cold storage for many new commodities has greatly extended the study of heat removal from various foods, and the information thus made available is invaluable in the calculation of reasonable storage charges and, with chill goods, in helping to decide upon suitable storage conditions. The important factors with any commodity are the specific heat, the latent heat, and the water content. That the first two are related to the third would seem to be obvious, but the relationship is not always clear and, in certain cases, remains obscure. A difficulty arises from the fact that the typical commodity is far from homogeneous and does not react uniformly to a falling temperature. Crystal formation is dependent upon the rate of freezing and it is easy to see how this will affect a commodity, different parts of which freeze at different temperatures: the commodity may be damaged by frost before its apparent freezing point is reached. This is an important consideration with chill goods and plays a part in determining the length of the storage period and in fixing the optimum storage temperature. Similar reasons call for caution when several different commodities are stored together in a chamber; the freezing points of cold store commodities vary, with a few exceptions, between 32° and 26° F. and there is also a wide range in specific heats and water contents.

Many cold stores are handling nothing but frozen produce, but frequently, due to transport delays and other causes, goods are received defrosted and must be hardened up. Other cold stores are receiving considerable quantities of goods generally received for chilling, but which to-day are being sent in increasing quantities for freezing down. To fix a reasonable rate charge, it is necessary to assess the refrigerating load to calculate what it is costing in power consumption. To assess the refrigerating load, the properties of the various commodities must be known. It is necessary to know the water content and fat content, and to calculate the sensible and latent heats of both, and the sensible heat of the remainder of the bone and tissue of the commodity.

It is essential for the cold storage operator to have a true and full appreciation of all factors that contribute to lengthen the life of the commodity and to prevent and avoid deterioration.

APPENDIX

TABLE 1.—Metrical Measures

The Cold Storage Industry frequently finds it necessary to transpose measures, particularly of weights, from the media used in other countries to that used in this country. The metrical system is used so much abroad that a conversion table is very often required.

Kilogramme	2·204 lb.	1,000 grammes.
Gramme	0·002 lb.	0·032 oz. Troy.
Metre	39·370 inches	1·093 yards.
Centimetre	0·393 inch	0·032 foot.
Litre	1·760 pint	0·220 galls.
Litre	61·027 cubic inches	0·035 cubic foot.

The above are the main equivalents used in Cold Stores but the following will also be found useful.

1 inch	=	25·4	millimetres.
1 foot	=	0·305	metre.
1 yard	=	0·914	metre.
1 centimetre	=	0·393	inch.
1 square inch	=	6·451	square centimetres.
1 square foot	=	0·093	square metre.
1 square yard	=	0·836	square metre.
1 cubic inch	=	16·386	cubic centimetres.
1 cubic foot	=	0·028	cubic metre.
1 cubic yard	=	0·764	cubic metre.
1 millimetre	=	0·039	inch.
1 kilometre	=	3280·9	feet.
1 square centimetre	=	0·155	square inch.
1 square metre	=	10·76	square feet.
1 cubic centimetre	=	0·061	cubic inch.
1 pound (lb.)	=	0·454	kilogramme.
1 cwt.	=	50·8	kilogrammes.
1 ton	=	1016·010	kilogrammes.
1 gallon of water	=	10	pounds.
1 gallon	=	277·46	cubic inches.
1 gallon	=	0·16	cubic foot.
1 gallon	=	4·54	litres.
1 cubic metre	=	1000	litres.
1 cubic metre of water	=	1000	kilogrammes.
1 lb. per square inch	=	0·07	kilogramme per square centimetre.
1 lb. per square foot	=	4·88	kilogrammes per square metre.
1 ton per square inch	=	1·575	kilogrammes per square millimetre.
1 gallon per square foot	=	48·91	litres per square metre.
1 B.T.U.	=	0·252	calorie.
1 ton of water	=	1	cubic metre approx.

TABLE 2.—B.T.U.s and Calories

The British Thermal Unit is the heat per pound required to cause one Fahrenheit degree increase in the temperature of water at ordinary pressure. The Calorie is the heat per unit required to raise the temperature of water one degree Centigrade. The unit of water used is usually the kilogramme, and consequently the calorie is known as the kilogramme calorie, written kg.cal.

British Thermal Units.	Calories.	British Thermal Units.	Calories.
3·96	1	118·8	30
7·92	2	138·6	35
11·88	3	158·4	40
15·84	4	178·2	45
19·8	5	198	50
23·76	6	217·8	55
31·68	8	237·6	60
39·6	10	257·4	65
47·52	12	276·12	70
59·4	15	295·92	75
67·3	17	316·8	80
79·2	20	336·6	85
88·12	22	356·4	90
95·04	24	376·2	95
99	25	396	100

TABLE 3.—Liquid and other Equivalents

1 cubic metre of water	=	220	Imperial gallons.
,, ,, ,,	=	1·308	cubic yard.
,, ,, ,,	=	61028	cubic inches.
,, ,, ,,	=	1000	kilogrammes.
,, ,, ,,	=	1000	litres.
,, ,, ,,	=	2204	lb.
,, ,, ,,	=	35·31	cubic feet.

1 % = 0·01 = 1/100	¼ % = 0·0025 = 1/400
2 % = 0·02 = 1/50	½ % = 0·005 = 1/200
5 % = 0·05 = 1/20	1½ % = 0·015 = 3/200
10 % = 0·10 = 1/10	12½ % = 0·125 = 1/8
25 % = 0·25 = 1/4	

1 gallon of water	=	277·274	cubic inches.
,, ,, ,,	=	0·16	cubic foot.
,, ,, ,,	=	10	lb.
,, ,, ,,	=	8	pints.
1 cubic foot of water	=	6·23	gallons.
,, ,, ,,	=	28·375	litres.
,, ,, ,,	=	0·028	cubic metre.
,, ,, ,,	=	62·35	lb.
,, ,, ,,	=	0·577	cwt.
,, ,, ,,	=	0·028	ton.

British ton of refrigeration	× 13·27	=	B.T.U./hour.
British Thermal Units	× 778	=	Foot lb.
Degrees Centigrade	× 1·8	=	Degrees F. −32.
Degrees Fahrenheit −32	× 0·555	=	Degrees C.
Feet	× 30·48	=	Centimetres.
Gallons	× 4·543	=	cubic centimetres.
Pounds per cubic foot	× 16·02	=	Kilogrammes/cubic metre.
Litres	× 0·035	=	cubic foot.

TABLE 4.—Relative Percentage Humidity for Ventilated Wet and Dry Bulb Thermometers

Depression of Wet Bulb

Relative Humidity Per Cent.

Dry Bulb Readings

°F.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
20	85	70	55	40	26	12	0													
21	85	71	56	42	28	15	1	0												
22	86	71	58	44	31	17	4	0												
23	86	72	59	46	33	20	7	0												
24	87	73	60	47	35	22	10	0												
25	87	74	62	49	37	25	13	1	0											
26	87	75	63	51	39	27	16	4	0											
27	88	76	64	52	41	29	18	7	0											
28	88	76	65	54	43	32	21	10	0											
29	88	77	66	55	44	34	23	13	3	0										
30	89	78	67	56	46	36	26	16	6	0										
31	89	78	68	58	47	37	28	18	8	0										
32	89	79	69	59	49	39	30	20	11	2	0									
33	90	80	70	60	51	41	32	23	14	5	0									
34	90	81	71	62	52	43	34	25	16	8	0									
35	91	81	72	63	54	45	36	27	19	10	2	0								
36	91	82	73	64	55	46	38	29	21	13	5	0								
37	91	83	74	65	57	48	40	31	23	15	7	0								
38	91	83	75	66	58	50	42	33	25	17	10	2	0							
39	92	83	75	67	59	51	43	35	27	20	12	5	0							
40	92	83	75	68	60	52	45	37	29	22	15	7	0							
41	92	84	76	69	61	54	46	39	31	24	17	10	3	0						
42	92	85	77	69	62	55	47	40	33	26	19	12	5	0						
43	92	85	77	70	63	55	48	42	35	28	21	14	8	1	0					
44	93	85	78	71	63	56	49	43	36	30	23	16	10	4	0					
45	93	86	78	71	64	57	51	44	38	31	25	18	12	6	0					
46	93	86	79	72	65	58	52	45	39	32	26	20	14	8	2	0				
47	93	86	79	72	66	59	53	46	40	34	28	22	16	10	5	0				
48	93	86	79	73	66	60	54	47	41	35	29	23	18	12	7	1	0			
49	93	86	80	73	67	61	54	48	42	36	31	25	19	14	9	3	0			
50	93	87	80	74	67	61	55	49	43	38	32	27	21	16	10	5	0			
51	94	87	81	75	68	62	56	50	45	39	34	28	23	17	12	7	2	0		
52	94	87	81	75	69	63	57	51	46	40	35	29	24	19	14	9	4	0		
53	94	87	81	75	69	63	58	52	47	41	36	31	26	20	16	10	6	1	0	
54	94	88	82	76	70	64	59	53	48	42	37	32	27	22	17	12	8	3	0	
55	94	88	82	76	70	65	59	54	49	43	38	33	28	23	19	14	9	5	0	
56	94	88	82	76	71	65	60	55	50	44	39	34	30	25	20	16	11	7	2	0
57	94	88	82	77	71	66	61	55	50	45	40	35	31	26	22	17	13	8	4	0
58	94	88	83	77	72	66	61	56	51	46	41	37	32	27	23	18	14	10	6	1
59	94	89	83	78	72	67	62	57	52	47	42	38	33	29	24	20	16	11	7	3
60	94	89	83	78	72	68	63	58	53	48	43	39	34	30	26	21	17	13	9	5

TABLE 5.—Temperatures—Centigrade and Fahrenheit

Centigrade to Fahrenheit = Temperature [illegible]

Fahrenheit to Centigrade = Temperature − 32 × 5/9.

° C.	° F.	° C.	° F.	° C.	° F.
100	212	62	143·6	24	75·2
99	210·2	61	141·8	23	73·4
98	208·4	60	140	22	71·6
97	206·6	59	138·2	21	69·8
96	204·8	58	136·4	20	68
95	203	57	134·6	19	66·2
94	201·2	56	132·8	18	64·4
93	199·4	55	131	17	62·6
92	197·6	54	129·2	16	60·8
91	195·8	53	127·4	15	59
90	194	52	125·6	14	57·2
89	192·2	51	123·8	13	55·4
88	190·4	50	122	12	53·6
87	188·6	49	120·2	11	51·8
86	186·8	48	118·4	10	50
85	185	47	116·6	9	48·2
84	183·2	46	114·8	8	46·4
83	181·4	45	113	7	44·6
82	179·6	44	111·2	6	42·8
81	177·8	43	109·4	5	41
80	176	42	107·6	4	39·2
79	174·2	41	105·8	3	37·4
78	172·4	40	104	2	35·6
77	170·6	39	102·2	1	33·8
76	168·8	38	100·4	0	32
75	167	37	98·6	− 1	30·2
74	165·2	36	96·8	− 2	28·4
73	163·4	35	95	− 3	26·6
72	161·6	34	93·2	− 4	24·8

TABLE 6.—Cubic Foot Weight of Different Commodities and Substances

Anthracite	93 lb.
Ash	38 ,,
Brass	504 ,,
Brass rolled	524 ,,
Brick	150 ,,
Butter	58 ,,
Beer	64 ,,
Cement	56 ,,
Charcoal	18 ,,
Cherry	42 ,,
Chestnuts	41 ,,
Dry Fruits	45 ,,
Eggs	25 ,,
Fat	58 ,,
Fat (Hog)	57 ,,
Fruits	22 lb.
Glass	157 ,,
Ice	58 ,,
Limes	75 ,,
Linseed Oil	58 ,,
Milk	64 ,,
Mercury	847 ,,
Masonry	143 ,,
Mud	120 ,,
Naphtha	53 ,,
Oil	56 ,,
Salt	45 ,,
Snow	5 ,,
Spruce	25 ,,
Tobacco	80 ,,

TABLE 7.—Properties of Calcium Chloride

Specific Gravity	Per cent. Calcium	Freezing Point, ° F.	Degrees Beaumé	Degrees Twaddell
1·01	1·1	31·1	1·4	2
1·02	2·3	30·2	2·8	4
1·03	3·5	29·1	4·2	6
1·04	4·7	28	5·6	8
1·05	5·8	27	6·9	10
1·06	7·0	25	8·2	12
1·07	8·2	24·6	9·5	14
1·08	9·2	23·4	10·7	16
1·09	10·4	21·7	12·0	18
1·10	11·4	20·3	13·2	20
1·11	12·5	18·5	14·4	22
1·12	13·5	16·5	15·5	24
1·13	14·6	14·4	16·7	26
1·14	15·6	12	17·8	28
1·15	16·6	9·7	18·9	30

TABLE 8.—Number of Feet Volume per Ton of Refrigerating Capacity

It has been roughly estimated that the amount of refrigeration required for a store of 100,000 cubic feet is 50 tons per day. Various factors, however, must be considered. The temperature to be maintained, the ratio of cubic feet to square feet of the insulated space, the construction of the building, and the method of insulating are of importance. The following table, based on the calculations of various authorities, will be found useful.

Cubic Feet	Sq. Feet Surface	Ratio	No. of cubic feet per ton of refrigeration at different Temperatures			
			0°	10°	15°	32°
1,000	600	0·6	1,940	2,376	2,808	3,670
10,000	3,300	0·33	3,600	4,400	5,200	6,700
30,000	6,200	0·206	5,670	6,930	8,190	10,710
50,000	9,000	0·18	6,480	7,920	9,360	12,240
100,000	16,000	0·16	7,200	8,800	10,400	13,600
200,000	28,000	0·14	8,100	9,900	11,700	15,300
300,000	32,000	0·106	11,030	13,486	15,938	20,840

TABLE 9.—Length of Piping required to Cool Various Volumes

Refrigeration required is governed by various factors. Generally, the amount of piping necessary can be roughly assessed as one running or lineal foot of 2-in. pipe for every nine cubic feet of space. The table below is, however, a better guide.

Volume	Lineal Feet of 2-in. Pipe per cubic foot			
	0°	10°	15°	32°
1,000 cubic ft.	0·825	0·165	0·11	0·0825
10,000 ,,	0·385	0·11	0·08	0·044
30,000 ,,	0·330	0·082	0·05	0·038
100,000 ,,	0·220	0·055	0·03	0·075

TABLE 10.—

Commodity	Type of Package	Approx. Av. Tare Wt. lb.	Approx. Packages per ton	Approx. Cu. Ft. per ton
Ale	Cases or barrels	15/35	35/17	100/170
Apples	Cases or crates	10/15	35	120
Apple rings	Cases	10/15	35	120
Apricots	,,	10/15	35	120
Apricots, dried	,,	10/15	35	120
Artichokes	,,	10/15	35	120
Asparagus	,,	10/15	35	120
Bacon—chill storage	Bales/boxes	5/27	9/3¾	150
,, —Wilts. cuts	Hessian bale	5	9	150
,, —middles	,, ,,	5	12	150
Bacon and hams	Full case	27	3¾	120
,, ,, ,,	Half case	19	7½	110
,, ,, ,,	Quarter case	17	13	110
Bananas	Crates and naked	15	...	250
Bass fish	Cases	15/20	40	150
Beans, dried	,,	10	35	120
,, green	Nets	1	74	250
Beef, fresh	Naked	...	...	...
,, fat	,,	...	...	...
,, lean	,,	...	...	...
,, chilled	,,	...	...	...
,, frozen hinds, B/in	Hessian	1½	13	130
,, ,, fores, B/in	,,	1½	14	130
,, ,, hinds, B'less	,,	1	17	125
,, ,, fores, B'less	,,	1	18	125
,, ribs and ponies	,,	1	17	115
,, crops	,,	1	21	115
,, cuts	,,	1	25	115
,, salt	Barrels	40	15	300
Beer	Cases or barrels	15/35	35/17	100/170
Beets	Baskets	7	35	120
Blackberries	Cases or baskets	5/10	40	120
Bloaters	Cases	10	40	150
Blood	Canisters	10	45	170
,, plasma	Bottles in cartons	7	56	90
Bluefish	Cases	15/20	40	150
Brisket	Naked	...	...	...
Bulbs	Trays	7	80	200
Butter	Cases or casks	7/15	40	80
Buttermilk	Churns and cans	15/5	100	150
Cabbage	Nets or crates	1/15	...	250
Canned goods	Cases	10	40	150
Carrots	Bags/crates	1½/15	50	150
Casings	Cases	10	25	120
Cauliflower	Bags/crates	1½/15	...	250
Celery	Cases	7	...	150
Cereals	Cartons	5	40	120
Cheese	Cases or crates	16	35	80
Cherries	Baskets/crates	5/15	30	250

mmodity Data

reezing Point Fahr.	Water Content per cent.	Specific Heat	Latent Heat	Storage Temperature ° Fahr.	Humidity per cent.	Storage Period
28	84	0·86	...	33	90	6 months
29	85	0·85	128	34	78	4 ,,
...	...	...	...	33	75	6 ,,
28	84	0·87	126	35	78	2 ,,
...	...	...	...	33	75	6 ,,
27	94	0·94	132	32	82	2 weeks
28	94	0·95	134	34	80	2 ,,
...	20	0·50	...	26	75	1 month
...	20	0·50	...	14	75	3 months
...	20	0·50	...	14	75	3 ,,
...	20	0·50	...	14	75	3 ,,
...	20	0·50	...	14	75	3 ,,
...	20	0·50	...	14	75	3 ,,
29	75	0·78	104	53	85	2 weeks
29	70	0·76	90	25/15	85	2 ,,
29	12	0·30	...	33	70	6 months
31	58	0·64	97	35	76	2 weeks
28	51	0·60	...	32	80	10 days
28	68	0·60	13	32	80	10 ,,
28	72	0·77	72	32	80	10 ,,
28	51	0·74	102	32	80	10 ,,
...	...	...	98	12	80	3 months
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	52	0·61	75	32	70	3 ,,
28	84	0·86	...	33	90	6 ,,
31	88	0·85	...	34	78	2 weeks
29	86	0·85	...	33	75	3 ,,
...	45	0·50	...	15/32	85	2 months/ 1 week
...	...	...	...	25	75	1 week
...	...	...	...	38	75	2 months
29	70	0·76	86	25/15	85	2 weeks
28	72	0·77	...	32	80	10 days
...	...	...	...	35	80	3 months
28	12	0·30	...	14	80	6 ,,
29	87	0·90	...	34	85	1 month
31	91	0·93	129	35	80	3 weeks
...	...	...	...	35	80	6 months
29	83	0·87	118	35	80	2 ,,
...	...	...	...	12	80	6 ,,
30	92	0·92	...	35	75	3 weeks
29	94	0·95	...	35	78	1 month
29	10	0·26	28	35	65	6 months
28	35	0·64	...	35	75	3 ,,
27	84	0·85	...	31	74	3 weeks

TABLE 10.–

Commodity	Type of Package	Approx. Av. Tare Wt. lb.	Approx. Packages per ton	Approx. Cu. Ft. per ton
Chestnuts	Bags/cases	2/15	40	200
Chocolate	Cartons	5	40	90
Cider	Cases	15	35	120
Cod, fresh	,,	25	30	200
,, brine	Cartons	5	...	...
Compound lard	Cases	10	40	80
Cream	Bottles in cases	10	25	120
Crêpe rubber	Cases	15	20	120
Cucumber	Baskets	7	35	120
Currants	Cases	10	20	150
Damsons	Cases	10	35	120
Dates, cooking	,,	10	35	120
,, dessert	Cartons in cases	10	35	120
Eggs, in shell	Cases	15	...	...
Egg, liquid, 44 lb.	Tin in carton	5/7	51	120
,, ,, 40 lb.	,, ,, ,,	5/7	56	120
,, ,, 30 lb.	,, ,, ,,	5/7	74	120
,, ,, 28 lb.	,, ,, ,,	5/7	80	120
,, ,, 22 lb.	,, ,, ,,	5/7	102	120
,, ,, 11 lb.	,, ,, ,,	5/7	204	120
,, ,, 5½ lb.	,, ,, ,,	5/7	408	120
,, dried/flake	Cases	30	18	110
Figs, cooking	Cases	10	35	120
,, dessert	Cartons in case	10	35	120
Fish, brine	Cases	10	35	120
,, cured or dried	,,	10	35	120
,, fresh	,,	25	30	200
,, frozen	,,	10	35	130
Flowers, cut	Cartons	5	...	...
Fruit juices	Cans in cartons	10	30	...
Furs	Bales	4	...	...
Game, fresh	Naked	...	...	...
,, frozen	Cases	10	35	140
Gooseberries	,,	10	35	140
Grapes	Cases or barrels	10/20	...	150
Grapefruit	Cases	10	35	140
Haddie, cured	Cases	10	35	130
Haddock, fresh	,,	25	30	200
,, frozen	,,	10	20	130

odity **Data** (*continued*)

ing t r.	Water Content per cent.	Specific Heat	Latent Heat	Storage Tem-perature ° Fahr.	Humidity per cent.	Storage Period
	...	...	...	33	75	3 months
	...	...	...	40	75	6 ,,
	...	...	...	40	85	3 ,,
	83	0·76	...	25/15	85	2 weeks
	83	...	...	− 5	80	6 months
	22	0·35	...	33	80	6 months
	59	0·68	84	32/−5	70	1 week/ 3 months
	...	...	...	31	75	1 month
	94	0·95	...	36	75	2 weeks
	85	0·77	...	33	75	2 ,,
	85	0·77	...	33	80	6 weeks
	83	0·82	...	40	75	6 months
	83	0·82	...	40	75	6 ,,
	70	0·76	100	31	78	9 months
	...	...	...	12	60	12 ,,
	...	...	...	12	60	12 ,,
	...	...	...	12	60	12 ,,
	...	...	...	12	60	12 ,,
	...	...	...	12	60	12 ,,
	...	...	...	12	60	12 ,,
	...	...	...	12	60	12 ,,
	...	...	...	32/12	60	3 weeks/ 12 months
	83	0·82	...	35	75	6 months
	83	0·82	...	35	75	6 ,,
	...	...	...	− 5	80	6 ,,
	45	0·56	65	32/15	78	1 week/ 3 months
av.	...	...	...	25/15	80	2 weeks
	...	...	...	− 5	80	3 months
	...	...	...	34	85	2 weeks
	36	0·64	...	34	80	6 months
	...	...	...	34	60	6 ,,
	60	0·68	...	33	70	2 weeks
	...	...	...	12	80	3 months
3	89	0·90	...	34	75	2 weeks
5	75	0·79	...	34	75	6 ,,
8	88	0·87	...	34	75	1 month
	45	0·55	65	32/15	75	1 week/ 3 months
	82	0·81	...	25/15	85	2 weeks 3 months
	...	...	...	− 5	80	6 months

TABLE 10.

Commodity	Type of Package	Approx. Av. Tare Wt. lb.	Approx. Packages per ton	Approx. Cu. Ft. per ton
Halibut	Cases	10	20	130
Hams, smoked	,,	10/20	13	140
Honey	,,	10	40	130
Hops	Bales	...	...	...
Ice	Blocks	...	70	100
Ice cream	Cases/cartons	30	200	300
Jams	Jars in cases	10	40	130
Kippers	Cases	7	40	140
Lambs, fresh	Naked	...	...	...
,, frozen	Stockinet	½	64	95
Lard	Cases	6	40	80
Lemons	Crates	10	25	150
Lettuce	Nets	2	...	...
Limes	Crates	10	20	150
Lobsters	Barrels	15	...	...
Maize	Cases	12	...	...
Malt	,,	...	...	...
Margarine	Cases/cartons	10/7	40/80	80
Meats, cooked	Cases	15	40	120
,, fresh	Naked	...	...	...
,, frozen	Cloth	1/2	Various	...
Melons	Crates	15	25	150
Milk	Cans	25	...	...
Milk powder	Cases	15	40	120
Mushrooms	Baskets	5	...	...
Mushroom spawn	Baskets/cases	5	...	...
Mutton, fresh	Naked	...	...	...
,, frozen	Stockinet	1	39	100
Nectarines	Crates	12	25	150
Nursery stock	Cartons	5	...	...
Nuts	Bags	2	40	200
Oatmeal	Cases	10	40	150
Offals, calf hearts	Cases, bags, cartons	7	33	110
,, calf kidneys	,, ,, ,,	7	41	110
,, calf livers	,, ,, ,,	7	36	110
,, calf sweetbreads	,, ,, ,,	7	36	110
,, lamb hearts	,, ,, ,,	7	33	110

nodity Data (*continued*)

zing nt hr.	Water Content per cent.	Specific Heat	Latent Heat	Storage Temperature ° Fahr.	Humidity per cent.	Storage Period
5	...	0·78	...	−5	80	6 months
..	...	...	...	28/14	70	2 weeks/ 3 months
..	88	0·87	...	34	75	6 months
..	...	...	...	34	70	6 ,,
.	...	...	...	25	80	...
..	67	...	...	−5	65	3 months
...	36	0·48	...	34	75	6 months
...	45	0·56	...	32/15	75	1 week/ 3 months
...	...	...	...	32	80	10 days
...	...	...	...	12	80	3 months
...	...	...	...	33	80	6 ,,
28	89	0·91	...	34	75	2 ,,
31	94	0·94	...	35	80	2 weeks
28	89	0·91	...	34	75	2 months
...	76	0·81	...	20	80	1 month
29	10	0·26	...	35	75	2 weeks
...	...	...	...	33	70	6 months
...	...	...	...	33	80	6 ,,
..	...	...	...	34/12	75	1 month/ 6 months
28 av.	...	...	...	32	80	10 days
..	...	...	...	12	80	3 months
.	...	...	...	35	75	2 ,,
27	87	0·90	124	34	85	1 week
...	...	...	...	35	75	1 month
26	88	0·90	...	36	80	2 weeks
...	...	...	...	34	75	1 month
...	...	...	...	32	80	10 days
...	...	...	...	12	80	3 months
28	80	0·89	...	35	75	6 weeks
...	...	...	...	34	85	2 ,,
23	...	0·21	...	34	78	3 months
29	10	0·26	...	35	65	6 months
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,

TABLE 10.–

Commodity	Type of Package	Approx. Av. Tare Wt. lb.	Approx. Packages per ton	Approx. Cu. Ft. per ton
Offals, lamb kidneys .	Cases, bags, cartons	7	41	110
,, lamb livers . .	,, ,, ,,	7	37	110
,, lamb sweetbreads .	,, ,, ,,	7	45	110
,, lamb throatbreads	,, ,, ,,	7	41	110
,, ox hearts . .	,, ,, ,,	7	30	110
,, ox kidneys . .	,, ,, ,,	7	37	110
,, ox livers . .	,, ,, ,,	7	45	110
,, ox tails . .	,, ,, ,,	7	40	110
,, ox sweetbreads .	,, ,, ,,	7	36	110
Onions	Crates	15	25	150
Oranges	,,	15	25	150
Oysters	Bags/barrels	5/20	...	...
Parsley	Nets	2	...	...
Parsnips	,,	2	...	...
Peaches	Cases	15	35	120
Peaches, dried . .	,,	10	35	120
Pears	,,	15	35	120
Peas, dried . . .	Cases/bags	10/2	35	120
,, fresh . . .	,,	15/2	35	130
Pineapples . . .	Cases	15	35	130
Plants, potted . . .	Naked	...	...	...
Plums	Cases	15	35	130
Pork, fresh . . .	Naked	...	...	...
,, frozen . . .	Cloth	1½	Various	...
,, boston butts . .	Cases	20	18	100
,, carcases, head on .	Cloth	1½	...	...
,, carcases, head off .	,,	1½	...	...
,, carcases, baconers .	,,	1½	...	...
,, cuts under 65 lb. .	Cases	10	40	100
,, cuts under 125 lb. .	,,	20	18	100
,, cuts over 125 lb. .	,,	25	14	100
,, picnic hams . .	,,	25	14	100
,, loins . . .	,,	10	44	95
,, salt . . .	Barrels	30	17	250
,, sides . . .	Cloth	1	16	130
,, shoulders . .	Cases	25	14	100
,, trimmings . .	,,	10	44	95
Potatoes	Crates	12	40	200
Poultry, fresh . . .	Cases	20	70	100
,, frozen . .	,,	20	70	100
Prunes	,,	15	25	130
Pulp, fruit . . .	Cans	10	30	100
Rabbits, fresh . .	Naked	...	...	...
,, frozen . .	Cases	7	31	110
Radishes . . .	Nets/bags	4	25	130
Raspberries . . .	Cases	10	20	130
Rhubarb . . .	Crates	10	30	130
Rice	Bags/cases	5	40	120

mmodity Data (*continued*)

eezing Point Fahr.	Water Content per cent.	Specific Heat	Latent Heat	Storage Temperature ° Fahr.	Humidity per cent.	Storage Period
...	...	...	...	12	80	3 months
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
29	87	0·90	...	35	80	2 ,,
28	86	0·87	...	34	75	2 ,,
28	80	0·84	114	32	90	2 ,,
31	91	0·92	...	35	80	2 weeks
30	83	0·86	...	33	80	2 months
29	89	0·92	...	33	80	1 month
...	...	...	...	33	75	6 months
28	84	0·90	...	35	80	1 month
...	...	...	...	33	75	6 months
30	74	0·91	...	33	80	2 weeks
29	89	0·92	...	40	75	1 month
...	...	...	...	34	85	2 weeks
29	78	0·83	...	35	80	6 ,,
...	...	...	...	32	80	10 days
...	...	...	...	12	80	3 months
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	55	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	32	70	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
...	...	...	...	12	80	3 ,,
28	74	0·91	105	40	80	2 ,,
29	73	0·79	108	32	80	10 days
...	60	0·68	...	12	80	3 months
29	83	0·86	...	40	75	6 ,,
28	36	0·64	...	34	80	6 ,,
29	60	0·80	...	32	80	10 days
...	60	0·68	...	12	80	3 months
28	91	0·93	...	35	80	2 weeks
28	85	0·90	...	36	75	2 ,,
30	94	0·94	...	36	75	2 ,,
29	10	0·26	...	35	65	6 months

TABLE 10.–

Commodity	Type of Package	Approx. Av. Tare Wt. lb.	Approx. Packages per ton	Approx. Cu. Ft. per ton
Seeds	Cartons/trays	4	35	130
Serums	Cartons	7	40	100
Skins	Bales	...	...	...
Strawberries . . .	Baskets	5	...	...
Syrup	Tins	10	30	100
Tangerines . . .	Crates	12	30	130
Tobacco	Bales	...	...	...
Tomatoes . . .	Crates/cases	12	...	...
Tongues, pickled . .	Barrels	30	16	...
Turnips	Bags	10	35	130
Turkeys	Cases	20	20	130
Vaccine . . .	Cases	10	20	130
Veal	Hessian	1	25	115
Watercress . . .	Baskets	5	...	...
Wines	Cases/casks	25	20	120
Woollen goods . .	Cases	15	...	...
Yeast	Cases/bags	10	20	130

nmodity Data (*continued*)

eezing Point Fahr.	Water Content per cent.	Specific Heat	Latent Heat	Storage Temperature ° Fahr.	Humidity per cent.	Storage Period
28	...	...	...	40	65	6 months
...	...	...	...	36/15	70	3 months/ 12 months
...	...	...	...	34	70	6 months
28	90	0·92	...	35	75	2 weeks
28	36	0·64	...	34	80	6 ,,
28	86	0·87	...	34	75	2 months
...	...	...	...	34	75	6 ,,
34	94	0·95	...	35	80	3 weeks
...	...	...	...	12	85	6 months
30	94	0·95	...	34	70	2 weeks
...	42	0·68	...	12	75	6 months
...	...	...	...	40	65	3 months
...	63	0·70	90	12	80	3 ,,
30	91	...	...	35	80	2 weeks
...	...	...	...	50	85	6 months
...	...	...	...	34	60	6 ,,
...	...	...	...	32	75	2 weeks

INDEX

16